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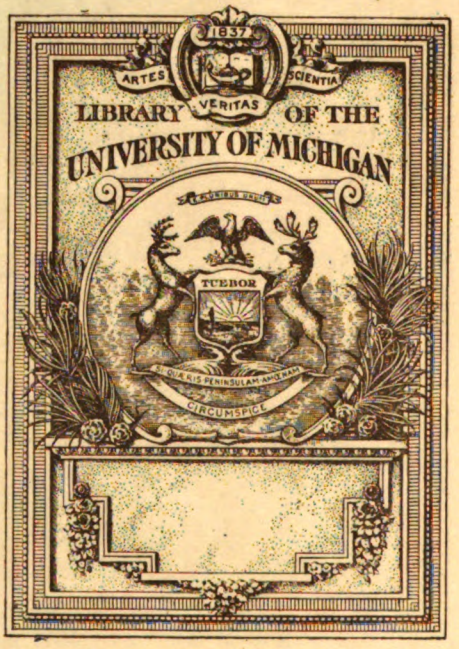

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FRANK W. DE WOLF, Chief

BULLETIN No. 37

GEOLOGY AND MINERAL RESOURCES
OF THE
HENNEPIN AND LA SALLE QUADRANGLES

BY
GILBERT H. CADY
Work in Cooperation with the U. S. Geological Survey

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LETTER OF TRANSMITTAL

STATE GEOLOGICAL SURVEY DIVISION, JUNE 20, 1919.

Francis W. Shepardson, Chairman, and Members of the Board of Natural Resources and Conservation.

GENTLEMEN:—I submit herewith a report on the Geology and Mineral Resources of the Hennepin and La Salle Quadrangles, by Gilbert H. Cady, and recommend that it be published as Bulletin No. 37. The field work was done under the joint auspices of the U. S. Geological Survey and the Illinois Geological Survey Division. Much of the Hennepin Quadrangle was surveyed by U. S. Grant of Northwestern University, and the remainder of that quadrangle and all of the La Salle quadrangle by Mr. Cady.

I believe the report will appeal to many classes of readers both in Illinois and without, as the area presents unusual problems for the geologist and attractive opportunities for industrial development, and is widely known not only by reason of the concentration there of mineral resources and industries, but perhaps as much for a historic and scenic interest rivalling that of any other part of Illinois.

Very respectfully,

FRANK W. DEWOLF, *Chief.*

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GEOLOGY AND MINERAL RESOURCES OF THE HENNEPIN AND LA SALLE QUADRANGLES

By Gilbert H. Cady

CHAPTER I—INTRODUCTION

Importance of Area

The area included in the Hennepin and La Salle quadrangles represents one of the wealthiest agricultural, manufacturing, and mining communities within the middle west. Valuable farm lands, world famous manufacturing industries, and extensive coal mining operations combine to make the area one which can hardly be equalled in commercial importance in the State outside of the large cities of Chicago and East St. Louis. In no small degree have geological factors contributed to the importance of the region, for the manufacturing, as well as the agricultural and mining wealth is drawn largely from the natural resources of the region. That such a region possesses geologic interest is to be expected, and this interest is greatly enhanced by the presence in the area of unusual structural conditions, and by exposures of rocks and buried glacial deposits that are more numerous and better uncovered than is commonly the case in the Prairie Province.

Further interest attaches to the region because of its nearness to Starved Rock State Park, the western end of which extends into the La Salle quadrangle. Deer Park a companion area of nearly equal scenic interest and beauty lies along Vermilion River wholly within the La Salle quadrangle. The valleys of the Illinois and the Vermilion and to a less degree the other valleys tributary to the Illinois possess scenic attractiveness of exceptional quality in contrast to the monotony of the landscape of the surrounding plains.

Location and Extent of Area

Parts of La Salle, Bureau, and Putnam counties and the cities of La Salle, Peru, Oglesby, Spring Valley, and Hennepin are included within these two quadrangles (fig. 1). A quadrangle is the unit of area chosen by the United States Geological Survey in the preparation of a topographic and geologic atlas of the entire country, and consists of a rectangular area of the earth's surface bounded by meridians and parallels, and hence does not con-

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form to state, county, or township boundaries. Each quadrangle measures 15 minutes of latitude by 15 minutes of longitude, a distance of approximately 17 miles north and south by 13 miles east and west. The Hennepin and La Salle quadrangles are bounded on the north and south respectively by parallels 41° 30′ and 41° 15′. The former parallel passes through the village of Triumph and the latter through the town of Hennepin. The east

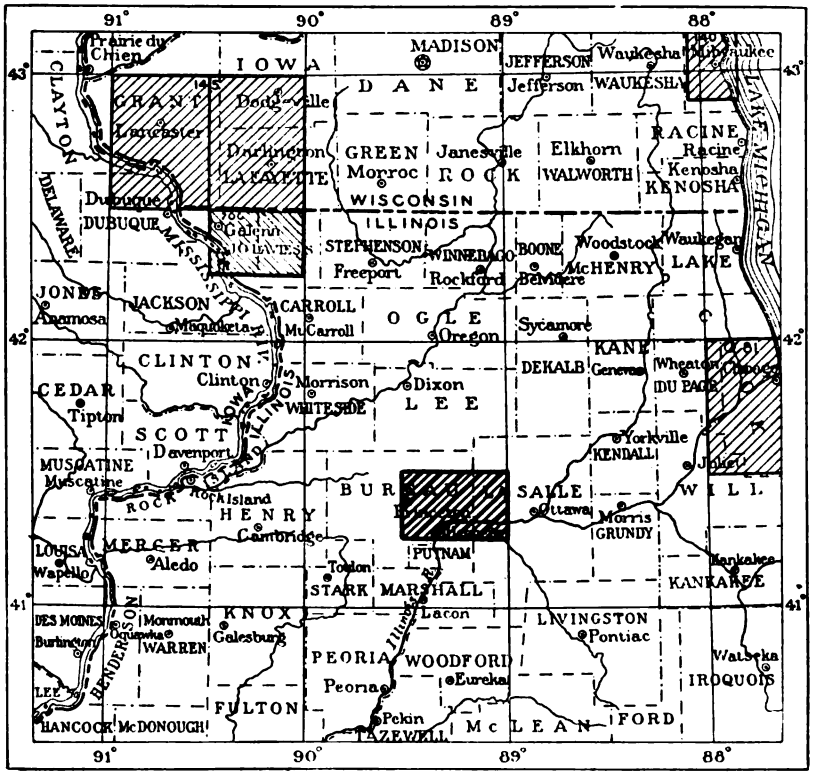

Fig. 1.—Map showing the location of the Hennepin and La Salle quadrangles.

boundary of the La Salle quadrangle is the meridian 89° which passes one-half mile east of Utica, and the west boundary of the Hennepin quadrangle, which passes through the village of Tiskilwa, is the meridian 89° 30′. The area of two quadrangles at this latitude and longitude is about 448½ square miles.

The district lies across the valley of the Illinois, the Hennepin quadrangle including that part of the valley known as the "Big Bend," and the La Salle quadrangle extending along the "Upper Illinois" to the head of navigation at Utica. The city of La Salle is 99 miles west of Chicago on the

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Rock Island Railroad, and Princeton is 104 miles from Chicago, on the Chicago, Burlington and Quincy Railroad. What was formerly the main line of the Illinois Central Railroad, but what is now the Freeport-Centralia division, crosses the Illinois River at La Salle. The terminus of the old Illinois Michigan Canal is at Peru and the Illinois and Mississippi or "Hennepin" Canal joins Illinois River near Bureau and extends up the valley of Bureau Creek, paralleling the main line of the Rock Island Railroad. The Chicago and Northwestern, the Chicago, Milwaukee, and St. Paul, and the Chicago, Indiana, and Southern railroads also enter the area. The Illinois Valley Electric Railroad of the McKinley System does an important interurban business in the district. Wagon roads are excellent, and there are several miles of the so-called "State-aid" roads radiating from the different towns. There is hardly a part of the district that is not readily accessible to automobile at any time.

Acknowledgments

The field work on the La Salle and Hennepin quadrangles was carried on in cooperation with the U. S. Geological Survey, and the results will be published as a folio[1] of the Geologic Atlas of the United States. The Hennepin quadrangle was surveyed largely by U. S. Grant. The eastern part of this quadrangle and all of La Salle quadrangle were surveyed by G. H. Cady. Assistance was given by T. E. Savage who collected some and determined all the fossils, and by Frank Leverett and W. C. Alden who gave aid and criticism in the study of the glacial deposits. Acknowledgment is herewith made of suggestions received from reading a manuscript, since published, by Carl Sauer[2] on the geography of the upper Illinois Valley especially concerning the history of the Illinois Valley. The maps and sketches illustrating the discussion were, in part, prepared by Miss Helen Skewes, of the Survey staff. To her and to other members of the State Geological Survey I am gratefully indebted for helpful criticism of the manuscript. For field supervision and for many suggestions in the organization of the report I owe thanks to Prof. U. S. Grant, with whom, originally, collaboration was intended.

[1] This folio is one of a series prepared in cooperation with the U. S. Geological Survey. The reports and maps were submitted by the State. Five folios have previously been published, namely Murphysboro-Herrin, No. 185; Tallula-Springfield, No. 188; Belleville-Breese, No. 195; Galena-Elizabeth, No. 200; and Colchester-Macomb, No. 208.

[2] Sauer, C. O., Geography of the upper Illinois Valley and history of development: State Geological Survey Bull. 27, 1916.

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CHAPTER II—GENERAL TOPOGRAPHIC AND GEOLOGIC RELATIONSHIPS

Preliminary Statement

These two quadrangles form a part of the Glaciated Plains province which includes the Prairie Plains and Lake Plains of Powell. All parts of the province have had a general history in common, recorded in the rocks and in the topography.[1]

Topography

The part of the Glacial Plains province included in and adjacent to this area forms the north central part of Illinois. The relief of this part of the State is not great, ranging from about 400 feet above sea level in the Illinois valley to about 1,000 feet on the higher hills. The greater part of the area is monotonously level or only gently rolling. The principal feature of the region is the valley of the Illinois. It is a flat-bottomed, steep-sided, and fairly regular valley, 1 to 3 miles in width and 250 feet and less in depth. Surface features of the region, here as elsewhere in the north central part of Illinois, aside from those due to stream erosion, are caused mainly by the irregular disposition of the glacial drift. Numerous morainic belts subparallel to the shore of Lake Michigan pass through Illinois rising locally as much as 200 to 300 feet above the drift plains separating them. They vary greatly in width from a fraction of a mile to possibly 25 or 30 miles, the average width being probably 2 or 3 miles. The moraines are conspicuous topographic features of the northern and central part of the State in a region otherwise generally level.

Drainage

North central Illinois lies entirely within the drainage basin of the Illinois, its northern boundary being arbitrarily regarded as the water shed of Rock River. The region is fairly well drained, but swamps are not uncommon in the river plains and the heads of some of the streams. The drift surface is sufficiently old so that the streams have drained many of the original irregularities in the drift, but here and there interstream areas are broad and characterized by shallow ponds and swamps. The streams in general occupy youthful rather than mature valleys.

[1] An outline of the geography and geology of the Glacial Plains province can be found in folios 185, 188, 195, 200, and 208.

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The pre-glacial drainage differed greatly from that of the present. It is believed that the Rock and possibly the Mississippi flowed south through Bureau County and continued southward in the approximate position of the present Illinois. Other streams tributary to this master stream entered it at various places, the position of which can be determined to some extent by outcrop but chiefly by drilling. Whether the Illinois existed east of Bureau County as a single pre-glacial stream is a debated question.

General Stratigraphic Relationships

Each Paleozoic system is represented in the strata underlying north central Illinois as far south as the south line of McLean County or as far west as Peoria County. The Cambrian system does not outcrop but is known from drilling and probably underlies the whole region. Strata of Ordovician age include two limestone members, one shale member, and a sandstone mem-

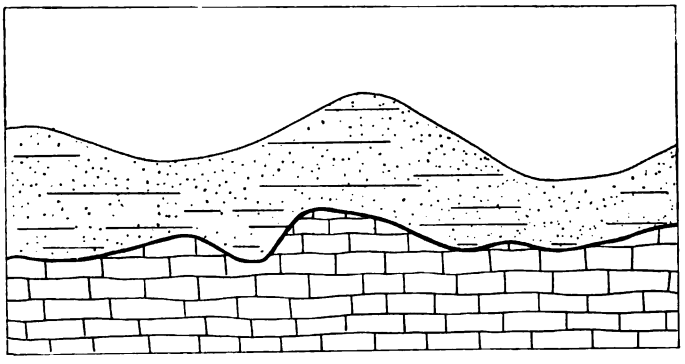

Fig. 2.—Diagram illustrating an erosional unconformity, such as that existing between the St. Peter sandstone and Shakopee dolomite. Reproduced by permission of the University of Chicago Press.

ber. The older limestone is the "Lower Magnesian" limestone of the upper Mississippi Valley. This is overlain by the St. Peter sandstone. The second limestone, which succeeds the sandstone, is of middle Ordovician age and is made up of the Platteville and Galena formations. These formations of the Ordovician probably underlie all the northern and central parts of the State except where locally removed by erosion. The Cincinnatian or upper Ordovician series, represented by the Maquoketa shales and shaly limestone, overlies the middle Ordovician limestones. These strata have been eroded off or were never deposited over the crest of the anticline in the northern part of the State, at least.

Rocks of the Silurian system underlie the southern part of the area but outcrop along the flanks of the anticline to the north. The Niagaran dolo-

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mite, which is the third of the important limestone formations of the Paleozoic group, is the only formation of the Silurian system known with reasonable probability to underlie the region. The knowledge of the distribution of this formation is based upon drilling.

The middle Devonian system is represented by the fourth important Paleozoic limestone formation. This formation does not extend east of the axis of the anticline and is possibly absent over much of the area to the west. Within north central Illinois it is known only from drilling. The upper part of the Devonian system is locally represented by shale.

Strata of Mississippian or Lower Carboniferous age probably underlie the southern and western part of the region, if drill cuttings from deep wells are correctly interpreted. This series contains the fifth important limestone member of the Paleozoic group in the interior province of the United States. This limestone formation and some of the underlying shales may extend into the region.

The strata of the Pennsylvanian or Upper Carboniferous series overlie

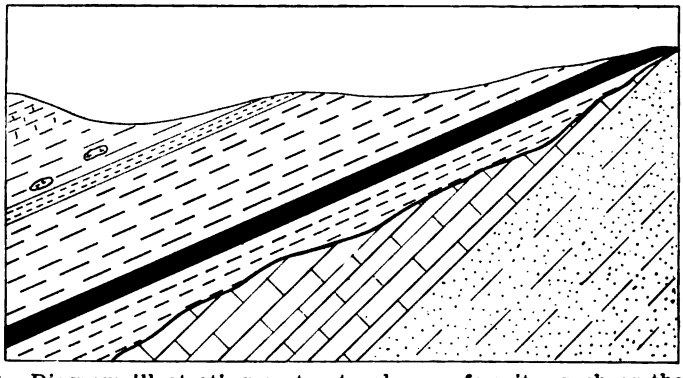

FIG. 3.—Diagram illustrating a structural unconformity, such as that existing between the coal-bearing strata and underlying rocks as at Split Rock and Deer Park. Reproduced by permission of the University of Chicago Press.

the Mississippian and the older rocks and occur as surface formations below the drift over much of north central Illinois, the outcrop crossing the northern part of La Salle and Bureau counties. The Pennsylvanian series is made up largely of shale, but includes much sandstone, and lesser amounts of limestone and coal. Many beds are lenticular but certain strata especially beds of coal and limestone, are continuous over thousands of square miles.

Because of the frequent oscillation of the sea over the interior region and the constantly changing position of the strand line that resulted, in no one locality in the interior region is there a complete stratigraphic record of the Paleozoic era. The many breaks in the record are marked by repeated erosional unconformities (fig. 2), by many instances of stratigraphic break

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apparent only from the interruption in the life record, and in some places by angular or structural unconformities (fig. 3).

There are at least five widespread and marked unconformities in the Paleozoic era. The interruption at the top of the Cambro-Ordovician limestone is general over large areas of the interior of the United States. The second break is below the Ordovician shale carrying the Richmond fauna. It is less conspicuous than the other four. The third is above the Ordovician (Richmond) shale and below the Silurian. There is a fourth general inter-

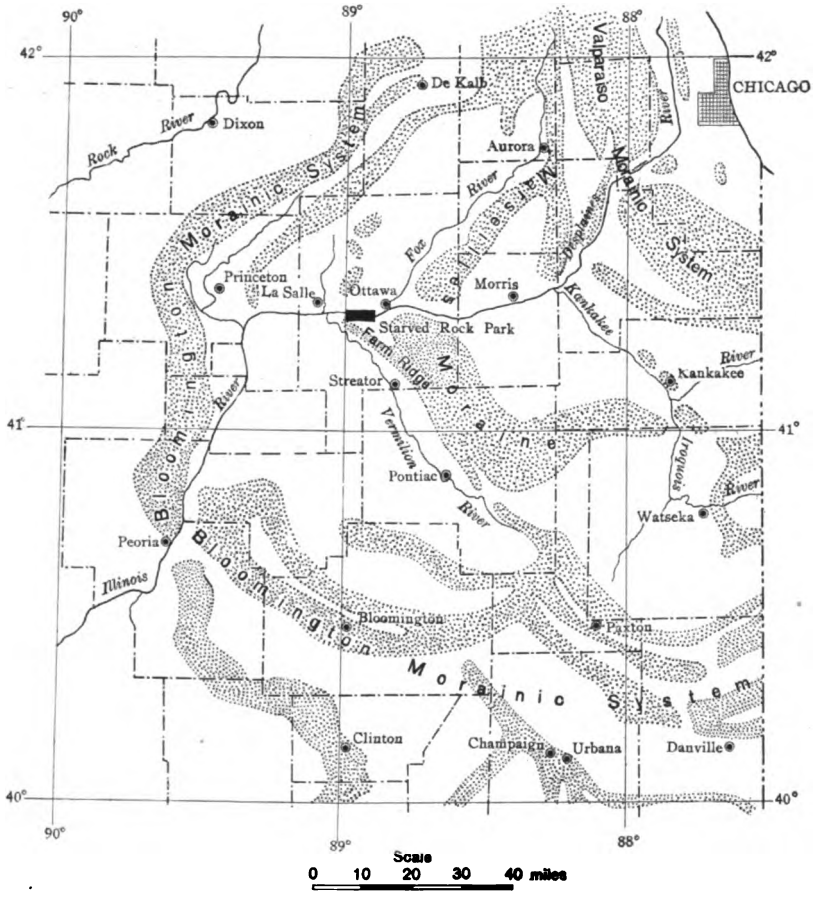

FIG. 4.—Map showing the distribution of moraines in northeastern Illinois. After Leverett, Frank, the Illinois Glacial Lobe: U. S. Geological Survey Monograph XXXVIII. Reproduced by permission of the University of Chicago Press.

ruption in the lower Devonian, for in this region the upper or middle Devonian rocks commonly rest upon the Niagaran limestone. The fifth and most conspicuous unconformity in the Paleozoic group of the interior

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region occurs throughout the province at the base of the Pennsylvanian series. This unconformity results from the overlap of the Pennsylvanian rocks upon the older, and more or less deformed, strata of various ages from Mississippian to early Ordovician.

Strata of Mesozoic or Tertiary age are not known certainly to exist in the region. It is possible that scattered bodies of gravel found below the drift may represent rewashed if not original late Tertiary deposition.

Deposits of glacial origin representing several stages of Pleistocene glaciation, the latest being the Wisconsin, and several interglacial epochs, have been found in the region. The areal distribution of the drift sheets and moraines in northern Illinois, is shown in Figure 4.

General Structural Relationships

The structure of northern Illinois including the north central part of the State is dominated by the general southward dip of the strata from the Wisconsin state line toward the center of the eastern interior coal basin. This general southward dip is modified by a broad arching along an axis bearing about N. 30° W., which crosses the Illinois valley about 1 mile east of La Salle and which is known as the La Salle anticline. Because of these structural relationships older strata tend to be exposed to the north and also along the axis of the transverse La Salle anticline. The prevailing dips are low, generally less than 1 degree. However, along a belt of steeply dipping strata on the west side of the axis of the La Salle anticline unusual inclination, as high as 52 degrees, has been observed, and strata commonly dip as much as 12 to 30 degrees. So far as known the strata have not been faulted, except possibly very locally and with off-sets of but a few feet.

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CHAPTER III—TOPOGRAPHY OF THE HENNEPIN AND LA SALLE QUADRANGLES

Relief

GENERAL FEATURES

The Hennepin and La Salle region has comparatively low relief, and as a rule, moderate slopes. Its altitude is low, although the area is far from the sea. The greatest altitude, about 810 feet above sea level, is near the northeast corner of the Hennepin quadrangle; the lowest point, about 435 feet above sea level, is in the channel of the Illinois at Hennepin on the south line of the area. The surface except where cut by the valleys of the Illinois and its tributaries is that of a drift-formed plain of upland prairie from 650 to 750 feet above sea level. Above the general plain three morainic ridges rise 20 to 100 feet. Two of them cross the Hennepin quadrangle from the northeast to the southwest, and the other extends along the east side of the La Salle area. Into the upland prairie the Illinois has carved a valley which is in some places more than 2 miles wide and more than 200 feet deep. It is the dominant topographic feature of the region; tributary streams, however, have also attacked the upland prairie and the moraines which rise above it, and have contributed to the topographic relief.

The area contains several topographic types—upland prairies, morainic hills with associated kames, valley features which include, besides the valleys, erosional and gradational terraces, flood plains, wash slopes, and alluvial fans, and finally, minor topographic features represented by dunes, hog-backs, and mine dumps.

UPLAND PRAIRIES

The uplands comprise more than half of the area of the quadrangles, are flat except where crossed by morainic hills, and are largely prairie.

The remarkably level character of the intermorainic upland plains is due to the presence of a mantle of nearly flat-surfaced glacial drift. The La Salle quadrangle has the more extensive flat upland, with a general slope from 700 feet above sea level near Arlington to 650 or 660 feet along the valley of Tomahawk Creek. Along the south boundary the upland elevation varies from about 700 feet near Granville to 620 near Lowell; and above the Illinois bluffs it averages 600 to 620 feet. The continuity of the flat upland on the Hennepin quadrangle is interrupted by the Arlington moraine, but in the northwest quarter of the area and between the Dover and Coal Hollow ridges the surface is very level. In Dover Township the plain has

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an elevation varying from 730 feet on the north to 700 feet on the south. The Malden plain and the plain east of Arlington vary from 700 to 660 feet above sea level.

The headwaters of many of the streams on the quadrangle rise in low, poorly drained, swamp-like areas of considerable extent, upon the uplands, so that definite divides between streams are not discernible.

MORAINIC HILLS

Above the general upland surface rise several ridges having a northeasterly or southeasterly trend. These ridges are formed of glacial drift, are without rock cores, and possess subdued undulating topography. They are regarded as weak morainic ridges.

Two belts of moraines are discernible. That to the west has its best development near Arlington, where it is about 3 miles in width and has a relief of about 100 to 125 feet above the upland prairie, rising to an altitude of about 810 feet. West of Arlington the moraine separates into two ridges which continue southwest in slightly diverging directions, and with constantly decreasing relief. Upon the west ridge, the Dover moraine, is situated the village of Dover and the city of Princeton. South of Princeton this moraine is scarcely discernible as a ridge because of dissection, but knob-and-kettle topography persists to the valley of Bureau Creek. South, across the valley of Bureau Creek, a weak ridge with morainic expression and possibly the continuation of the Dover moraine can be followed east to Illinois Valley. The east or Coal Hollow moraine lies between East Bureau Creek and Brush Creek passing near but east of Coal Hollow. Toward Illinois Valley it becomes less conspicuous as a ridge but the topography is morainic to the bluff line.

Another ridge, the "backbone" extends southeast from secs. 4 and 9, Waltham Township, north of Utica, to the Vermilion River east of La Salle. It is interrupted by Illinois Valley but south of the Illinois extends to the southeast as the Farm Ridge moraine, only the west fringe of which is in the La Salle quadrangle. This moraine has an altitude of about 700 feet above sea level in this area and a relief of 50 to 60 feet above the adjacent upland prairies.

The surface of each ridge is undulating, commonly in open curves, but locally there are present the small hills and basins of typical knob-and-kettle topography. In the vicinity of Arlington in sec. 7, T. 17 N., R. 11 E., one such kettle of considerable size has until recently been occupied by a lake or swamp.

Near Zearing in secs. 21 and 22, Berlin Township, and also near Hallowayville in secs. 14 and 15, Selby Township, small hills of sand and gravel having a relief of 25 to 40 feet above the surroundings lie on or adjacent

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to the Coal Hollow moraine. These features are indicated on the areal geology map as kames, and are thought to have been formed by streams flowing in the ice near the front of the glacier.

VALLEY FEATURES

The topographic features of the valleys include not only the erosion slopes and cliffs, but also terraces due to erosion, others due to deposition, and finally the extensive flood plain.

The surface of the quadrangles is fairly well dissected but with the exception of the Illinois none of the valleys is large. The valley of the Illinois varies in width from about 1 mile near Spring Valley to 1½ miles at Utica and 2¼ miles at Hennepin. It is about 200 feet deep. In general, tributary valleys cut into the rock, such as the lower part of Little and Big Vermilion rivers, Pecumsaugan Creek, Cedar Creek, and Clark Run, are narrow and steep sided, some being gorges or canyons. Such valleys are confined to the La Salle quadrangle. Other valleys, especially those in Hennepin quadrangle,

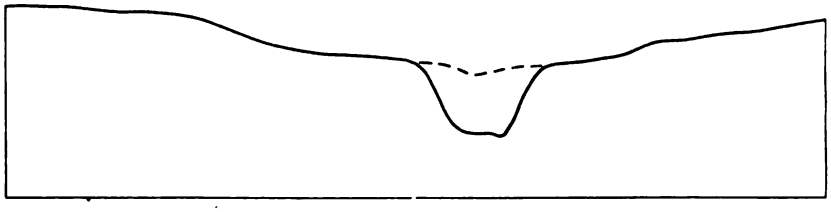

FIG. 5.—Profile across a typical valley.

but also the upper parts of the valleys in La Salle quadrangle, which are cut into the glacial drift, are broader and have less precipitous walls. Steep cuts in the drift, however, are not uncommon along these streams. In some places broad swampy areas connect the heads of valleys. For example, in Troy Grove Township (T. 35 N., R. 1, E.), the tributaries that enter Little Vermilion River from the west and the headwaters of Spring Creek together drain an extensive flat area. Similar divides separate the headwaters of Cedar and Allforks creeks, and of Negro and Brush creeks.

Bordering the larger valleys is found a stream-worn bench, which along the Illinois lies outside the inner valley at an altitude of 590 to 610 feet. The head portions of other valleys are commonly open and have gently-sloping sides. Downstream a narrow, steep-sided valley is commonly cut below the floor of the wider valley (fig. 5). The bench thus located outside the inner gorge shows evidences of stream scour upon the bed rock in places, as near the Pecumsaugan. The chief features of this bench seem to be due to erosion rather than to gradation.

Similar, but gradational terraces, that are probably contemporaneous

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with one another, are distributed at altitudes varying from 560 to 580 feet along the Illinois and at higher elevations along the tributary streams. One such feature known as the Hennepin terrace, borders the Illinois northeast from Hennepin for 4 or 5 miles. It represents a former alluvial filling of Illinois Valley, probably a valley train originating at the Marseilles moraine, which forms the west slope of the Fox River drainage basin. The terrace is apparently similar in character and in history to others at a similar height which border the Illinois between Hennepin and Peoria. It is represented also along most of the large tributaries. Lower and younger terraces are also

FIG. 6.—Ridge (hog-back) on the upland east of the Little Vermilion River caused by the outcropping of the La Salle limestone along the La Salle anticline.

very common. In the vicinity of Depue, for instance, such a terrace lies 10 to 20 feet above the flood plain of the Illinois, and 460 to 480 feet above sea level. All of the valleys are characterized by terraces, but correlation is difficult.

A flood plain occupies the floor of most of the valleys within the area. The most notable example is Illinois Valley. The flood plain of the Illinois begins in sec. 18, Utica Township, and continues downstream beyond the limits of the quadrangles. Above sec. 18 the river is entrenched in the valley floor which here is rock and represents the floor of the channel of an ancient river of large size. The flood plain of the Illinois is conspicuously regular in width and is remarkable for the straightness of its boundaries, but many irregularities due to cusps and valley embayments, in places deep and amphi-

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theater-like, affect the flood plains of the smaller streams. The valley floors are not uncommonly built up at the foot of the valley bluffs by wash and fans; particularly is this true in Illinois Valley, and in places abandoned channels are occupied by beds of peat.

MINOR TOPOGRAPHIC FEATURES

Miscellaneous topographic features include dunes, which are distributed here and there over the Hennepin terrace as shown on the areal geology map; the out-cropping edges of the upturned La Salle limestone, which forms small hog-backs in secs. 11, 13, and 14, La Salle Township (fig. 6); and, finally, mine dumps. These last are conical piles of rock refuse supplied from the mines, not uncommonly reaching a height of 100 feet or more (fig. 7). These

FIG. 7.—The rock dump at Mine No. 3, Spring Valley Coal Company.

are visible for considerable distances if located upon the upland prairie, as at Cherry and at Ladd.

DRAINAGE

The greater part of the quadrangles is well drained, but somewhat extensive flood plain areas along the Illinois are subject to frequent overflow, and part of the upland is so flat that the water from heavy rains disappears slowly. The run-off from the upland is more rapid near Illinois Valley than it is at a distance, where the headwaters of several streams terminate in swampy areas that form indistinct divides between adjacent drainage basins.

The master stream of the area toward which all others flow is Illinois River.

Of the smaller streams the most important is Vermilion River, which although it drains only about 18 square miles of La Salle quadrangle is the trunk stream for a large part of southern La Salle County and for large areas in Livingston County. In the Hennepin quadrangle Bureau Creek is the largest tributary of the Illinois, but like the Vermilion it drains a large outside area.

Other streams draining large parts of the Hennepin and La Salle quad-

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rangles north of the Illinois are Little Vermilion River, Spring Creek, Negro Creek, East Bureau Creek, and its tributary Brush Creek. These latter two streams drain a large part of the Hennepin quadrangle. On the south side of the Illinois Valley prominent streams are Cedar Creek, and Allforks Creek.

Culture

All the large towns of the area except Princeton are located along the edge of Illinois Valley. La Salle, Peru, Depue, and Hennepin are located at points where the river swings toward the bluff. Peru and Hennepin had an important stage in their histories when considerable traffic went up and down the Illinois. The practically abandoned water front of Peru is one of its places of historical interest. Princeton, the one large town off Illinois River, is the center of a large farming community in Bureau County. The populations of La Salle, Peru, Spring Valley, and Princeton, the four largest cities in the area in 1910, were 11,537, 7,984, 7,035, and 4,131 respectively. The population of the rural communities is relatively dense, the township without cities or villages generally having between 600 and 1,000 people.

The occupations of the people can be roughly divided as follows: farming and its attendant industries, mercantile pursuits, coal mining, zinc smelting, the manufacture of cement, clock making, and the minor industries, such as the manufacture of brick and tile and of plows and farm implements, and clay mining.

The area is well provided with transportation facilities. The highways are numerous and well maintained. The great amount of available gravel affords abundant cheap road metal. Direct roads between cities and towns are usually well ballasted. Dirt roads are frequently dragged and scraped. Several railroad lines enter the area, viz: Chicago, Rock Island and Pacific Railway; Chicago, Burlington and Quincy Railway; Illinois Central Railroad; Chicago and Northwestern Railway; Chicago, Milwaukee and St. Paul Railway; Chicago, Indiana and Southern Railroad; La Salle and Bureau Counties Railroad.

The main lines of the first three railroads in the list pass through the area. The last line named is a freight road only. An electric interurban line is operated between Princeton, Bureau, Spring Valley, Ladd, Peru, La Salle, Utica, and other towns lying to the east as far as Joliet. There are two canals: one in the La Salle quadrangle (Illinois and Michigan Canal) passes along the foot of the Illinois bluff as far as Peru; the other, in the Hennepin quadrangle (Illinois and Mississippi Canal), begins at Illinois River near Bureau and runs westward up the valley of Bureau Creek past Tiskilwa. Neither of these canals is much used at present except by pleasure boats. Illinois River is navigable the whole length of the area by shallow draught boats, and by larger boats below Peru.

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CHAPTER IV—STRATIGRAPHY

General Character of the Rocks

The rocks of the Hennepin and La Salle quadrangles, including both those that outcrop and those that are known from well records only, are sedimentary and consist in part of indurated strata, Carboniferous and older, and in part of unconsolidated sediments of Quaternary and later age. (See fig. 8).

The rocks known from outcrop or only from drilling include in ascending order the Oneota dolomite, the New Richmond sandstone and the Shakopee dolomite of the Prairie du Chien group of Lower Ordovician age; the St. Peter sandstone, and the Platteville-Galena limestone and dolomites of Middle Ordovician age; the Maquoketa shales and limestone of Upper Ordovician age; the Silurian dolomite, probably of Niagaran age; possibly Devonian limestone; and the Pottsville, Carbondale, and McLeansboro formations of the Pennsylvanian series. Of these the Oneota dolomite, New Richmond sandstone, Maquoketa formation, and the Silurian and Devonian rocks are known only from drilling explorations. The total explored thickness of indurated strata is about 2,300 feet.

The unconsolidated boulder tills, gravels, silts, and buried soils represent the deposition of probably three periods of glaciation in the Quaternary period. There is, in addition some indication of a thin deposit of gravel overlying the Pennsylvanian rocks and underlying the Quaternary deposits. The maximum known thickness of the sediments of glacial origin is 343 feet.

Within Illinois Valley and its tributary valleys there have accumulated partly on glacial drift and partly on the older rocks fluviatile sediments composed of sand and gravel, silt, and alluvium to a maximum known thickness of about 100 feet.

Thus the total known thickness of consolidated and unconsolidated sediments amounts to about 2,800 feet. If to this thickness is added the additional thickness of other strata probably underlying the area and known from drilling in the adjacent Ottawa quadrangle the total thickness of sedimentary strata known in the region amounts to 3,500 to 3,600 feet.

The following section is a compilation of the records of several wells in the area showing the succession of the pre-Pennsylvanian strata encountered. The succession from the Pennsylvanian contact to the base of the Niagaran is taken from the record of the Mineral Point Zinc Company's well at Depue.[1]

The strata will be described from below upward in the order of deposition.

[1] Udden, J. A., Some deep borings in Illinois, Ill. State Geological Survey Bull. 24, p. 49, 1914.

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The Maquoketa, Galena, and Platteville succession is from the record of the Chicago Portland Cement Company's well at Oglesby. The Shakopee and New Richmond sections are from the record of the well of the Illinois Zinc Company at Peru, and the Oneota section is from the record of the well at St. Bede College, Spring Valley.

Section of the pre-Pennsylvanian strata in the Hennepin and LaSalle quadrangles compiled from the records of several artesian wells.

System, formation and bed	Thickness	Actual depth	Total thickness
Pennsylvanian series: (*Pennsylvanian-pre-Pennsylvanian contact*)	*Feet*	*Feet*	*Feet*
Shale, gray, with pyrite and coal and white, dolomitic limestone	..	.....	...
Devonian or Silurian system (462 feet):			
Limestone, dolomitic, white and gray	34	422	34
Limestone, grayish white, cherty	13	435	47
Dolomite, porous, with drusy quartz and chert	85	520	132
Dolomite, porous, and cavern clay and sand	20	540	152
Dolomite, porous, with quartz and chert	15	555	167
Limestone, dolomitic, cream-white, cherty	47	602	214
Niagaran series:			
Limestone, dolomitic, straw-colored, porous	6	608	220
Limestone, dolomitic, like above, with pyrite	7	615	227
Limestone, dolomitic, like above; fossils	17	632	244
Limestone, dolomitic, light gray, porous	18	650	262
Limestone, dolomitic, white, fine	23	673	285
Limestone, dolomitic, straw colored	27	700	312
Limestone, dolomitic, white, compact	20	720	332
Limestone, dolomitic, straw-gray, coarse	17	737	349
Limestone, dolomitic; shale, green and gray	28	765	377
Limestone, dolomitic, gray	22	787	799
Limestone, dolomitic, white, compact; some chert	55	842	454
Limestone, dolomitic, gray, with pyrite	8	850	462
Ordovician system (1351 feet):			
Upper Ordovician series:			
Maquoketa formation (190 feet):			
Upper shale member:			
Limestone, green, porous, shale	10	970	472
Shale, fine, greenish	20	990	492
Shale, hard, fine, greenish gray	5	995	497
Shale, fine, light blue, calcareous	5	1,000	502
Upper limestone member:			
Shale, calcareous, with small amounts of white crystalline limestone	20	1,020	522
Limestone, coarse gray; shale, gray	20	1,040	542
Middle shale member:			
Shale, fine, bluish	20	1,060	562
Lower limestone member:			
Limestone, gray to white, crystalline	25	1,085	587
Limestone, gray to white, crystalline, and shale, bluish gray, calcareous	10	1,095	597
No sample	10	1,105	607
Shale, gray, calcareous; limestone, white, crystalline	20	1,125	627
Lower shale member:			
Shale, bluish gray, non-calcareous	25	1,150	652

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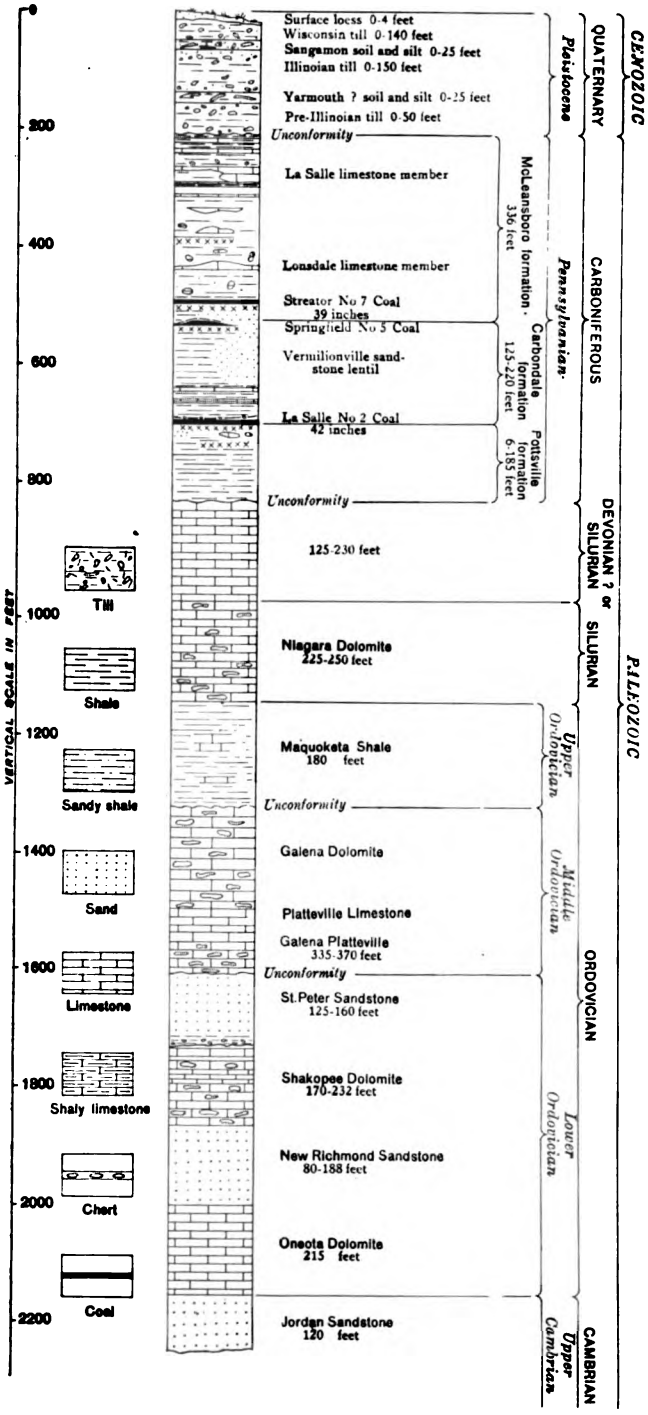

FIG. 8.—Generalized columnar section of the rocks of the Hennepin and La Salle quadrangles.

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Section of the pre-Pennsylvanian Strata in the Hennepin and La Salle quadrangles—Concluded

System, formation and bed	Thickness	Actual depth	Total thickness
	Feet	*Feet*	*Feet*
Middle Ordovician series:			
Galena and Platteville formations (380 feet):			
Galena:			
Dolomite, calcareous, brown: magnesia decreases downward	130	1,280	782
Limestone, dolomitic, brownish	100	1,380	882
Limestone, dolomitic, sandy, brown	40	1,420	922
Platteville?:			
Limestone, thin bedded, soft	10	1,430	932
Limestone, dolomitic, sandy, buff	75	1,505	1,007
Dolomite and shale	10	1,515	1,017
Dolomite, dark brown	15	1,530	1,032
St. Peter sandstone (120 feet):			
Sandstone, white, colorless	120	1,488	1,152
Lower Ordovician series:			
Prairie du Chien group (661 feet):			
Shakopee formation (190 feet):			
Dolomite, light brownish gray; shale, gray	12	1,500	1,164
Sandstone, colorless, coarse	4	1,504	1,168
Dolomite, light brown; shale; limestone	38	1,542	1,206
Sandstone	5	1,547	1,211
Dolomite, gray, semi-crystalline	4	1,551	1,215
Dolomite, gray, slightly calcareous	25	1,576	1,240
Dolomite, brownish	8	1,584	1,248
Dolomite, white, calcareous	37	1,621	1,285
Dolomite, white; shale, gray; sandstone	5	1,626	1,290
Dolomite, white, calcareous, flinty	6	1,632	1,296
Dolomite, white, calcareous	24	1,656	1,320
Dolomite, brown to buff	18	1,674	1,338
Dolomite and sandstone	4	1,678	1,342
New Richmond formation (136 feet):			
Sandstone; colorless quartz grains	37	1,715	1,379
Sandstone and dolomite	9	1,724	1,388
Sandstone; colorless quartz grains	16	1,740	1,404
Sandstone and dolomite	14	1,754	1,418
Sandstone, coarse, colorless	46	1,800	1,464
Sandstone and dolomite	8	1,808	1,472
Dolomite and sandstone	3	1,811	1,475
Sandstone, fine; little limestone	3	1,814	1,478
Oneota formation (335 feet):			
Dolomite	215	2,180	1,693
Sandstone	120	2,300	1,813

Cambrian System

Cambrian rocks have not yet been reached by the drill in this area, but probably underlie the known rocks, inasmuch as wells at Ottawa and near Marseilles, towns in the eastern part of La Salle County, reach Cambrian sandstone. The full thickness of the Cambrian strata in Illinois has not been determined but at least 1,000 feet is probably present in La Salle County. The Cambrian formations of Wisconsin range in age from middle to upper

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Cambrian and the rocks underlying Illinois are probably of similar age. In Illinois as elsewhere the Paleozoic sedimentary systems lie upon the metamorphic and igneous rocks of the pre-Cambrian systems.

Ordovician System

Ordovician rocks underlie the entire area of both quadrangles. East of the La Salle anticline they include all strata from the lower limestone encountered in the wells at Utica to the youngest outcropping rocks underlying the Pennsylvanian strata. West of the anticline they extend upward to the base of the heavy Niagaran limestone encountered in the deep drilling. The maximum thickness of Ordovician rocks encountered in the quadrangle is 1,330 feet in the well at St. Bede College.[1]

The divisions of the Ordovician represented in the area are, in ascending order, as follows: Oneota, New Richmond and Shakopee formations of the Prairie du Chien group and the lower Ordovician series, St. Peter, Platteville, and Galena formations of the Middle Ordovician series; and Maquoketa formation of the Upper Ordovician series.

Lower Ordovician Series

PRAIRIE DU CHIEN GROUP

The name Prairie du Chien was applied by Bain and Grant in 1906 to the group of formations to which Owen in 1840 had given the name Lower Magnesian in contrast to the Upper Magnesian, a series under which were included all beds between the top of the Niagaran dolomite and the base of the Galena dolomite.[2] The Prairie du Chien group includes the strata encountered in the wells at Utica and the dolomitic limestones outcropping along Illinois and Little Vermilion rivers and Pecumsaugan Creek beneath the St. Peter sandstone. Several wells in the vicinity of Utica and Deer Park and one previously mentioned at St. Bede College between Peru and Spring Valley have penetrated the Prairie du Chien formations. A maximum thickness of 650 feet seems to have been encountered, though the record is not very satisfactory.

ONEOTA FORMATION

The Oneota formation in this region is known only from the records of a few wells in La Salle County, several of which are outside the quadrangles. The upper part is a dolomite about 200 to 225 feet thick. Below it are various

[1] Udden, J. A., Some deep borings in Illinois, Ill. State Geol. Survey Bull. 24, p. 47, 1914.

[2] Bain, H. F., U. S. Geol. Survey Bull. 294, p. 17, 1906. Grant, U. S., Wis. Geol. & Nat. Hist. Survey Bull. 14, p. 25, 1906. Owen, D. D., Ex. Doc. 239, 26th Cong. 1st sess., p. 17, 1840.

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thicknesses of dolomite, shale, and sandstone, but the dolomitic members predominate for about 300 feet, after which the arenaceous members are in excess. It is thought that the division between the Ordovician and Cambrian systems occurs near the upper part of the lower arenaceous series. The well at St. Bede College penetrates a sandstone below the upper dolomite member of the Oneota formation.

NEW RICHMOND FORMATION

The New Richmond of the area is known only from drill records. It is an important water-bearing horizon. In thickness it is known to vary from

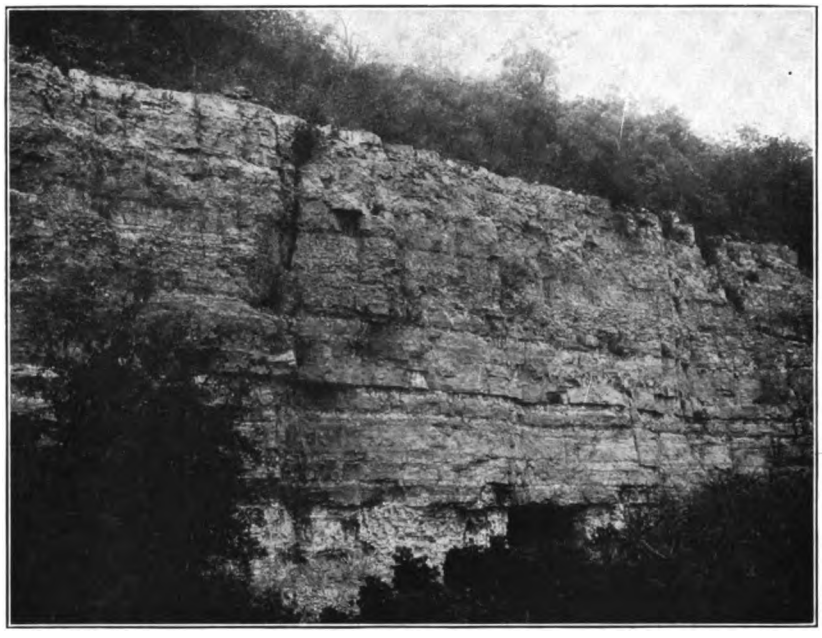

FIG. 9.—Shakopee dolomite outcropping along the north bluff of Illinois River between Split Rock and Utica. Reproduced by permission of the University of Chicago Press.

80 feet as reported in the well at St. Bede College to 188 feet as reported in a well at Deer Park. The sandstone resembles the St. Peter sandstone and the two formations are frequently confused by drillers. Examination of drill cuttings from the Illinois Zinc Company's well at Peru indicates that the grains of the St. Peter sandstone are smaller than those of the New Richmond, about two-thirds of the grains from the upper sandstone being less than .473 mm. (.0132 inch) in diameter, whereas only about one-fourth of the grains from the older sandstone are that small. The formation contains some lime-

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stone as shown in the compiled section of the pre-Pennsylvanian rocks shown above.

SHAKOPEE DOLOMITE

Distribution and physiographic expression.—The Shakopee dolomite is the only member of the Prairie du Chien group that outcrops in Illinois. Within the La Salle quadrangle it is known from outcrop and from drill records. It varies in thickness from 170 to 232 feet. The areas underlain by the Shakopee dolomite are confined almost entirely to that part of La Salle quadrangle lying north of Illinois River and east of the axis of the La Salle anticline. The single exception is a small area along the south bank of the Illinois in secs. 19 and 20, Deer Park Township, (T. 33 N., R. 2 E.). The areal geology maps indicate the position of the outcrops.

FIG. 10.—Shakopee dolomite, showing the brecciated structure.

Wherever the dolomite is present along streams, gorges have been cut into the rock resulting in cliffs that in places reach a height of 60 to 75 feet (fig. 9). In the valley of the Illinois near Utica and on the upland west of Pecumsaugan Creek the surface of the Shakopee dolomite is very irregular and gives rise to a characteristic topography marked by small knolls interspersed with shallow basins, resembling somewhat knob-and-kettle topography of a terminal moraine.

Fossils and correlation.—The fossils in the Shakopee dolomite are rare. Along Little Vermilion River large globular masses of concentric structure

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resembling cryptozoa, are quite common. The known fossils consist almost entirely of gastropods in a very poor state of preservation. Because of this paucity of fossils, correlation of faunas has not been attempted, dependence being placed rather on similarity of lithology and stratigraphic sequence in this area and in Wisconsin.

Lithologic character.—The Shakopee dolomite varies in color from light gray to buff, and in texture from fine grained and laminated to coarse grained and porous. Certain physical characters of the Shakopee point to deposition in agitated water, though not necessarily near shore. There is considerable sand which locally occurs in layers that may be ripple marked. There are numerous beds of brecciated dolomite (fig. 10), made up of fragments of

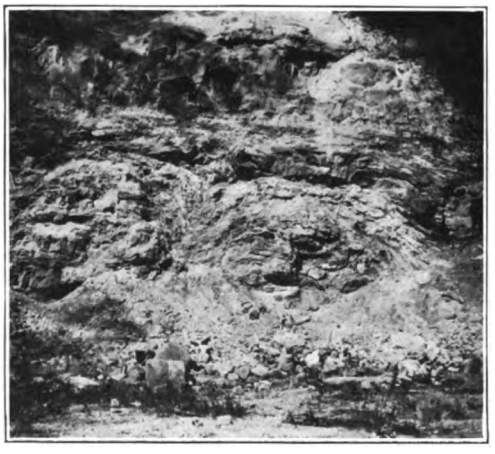

FIG. 11.—The contact of St. Peter sandstone and Lower Magnesian limestone near Split Rock (vertical scale about 16 feet to 1 inch).

dolomite rarely over an inch in diameter embedded in a sandy matrix. Two beds of thinly laminated, fine-grained dolomite, thought to have been deposited in protected lagoons as mud derived from wave-scoured ridges, are found near the middle of the formation. The upper part of the formation contains considerable oolite. Finally, the lithologic variation in the beds indicates fluctuation of conditions of sedimentation characteristic of shallow-water deposition.

Stratigraphic relations.—The base of the Shakopee dolomite is not exposed in this region, so that this stratigraphic relation with the underlying New Richmond sandstone is unknown. The contact with the St. Peter sandstone above is exposed in a number of places and in each is unconformable (fig. 11).

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MIDDLE ORDOVICIAN SERIES

ST. PETER SANDSTONE

CHARACTER AND DISTRIBUTION

Upon the Shakopee dolomite lies the St. Peter sandstone, so named from its occurrence along the St. Peter (now known as Minnesota) River in Minnesota.

The following table shows the thickness of the St. Peter sandstone in nine wells where accurate measurements were made:

Thickness of the St. Peter sandstone in nine wells of the Hennepin and La Salle quadrangles

	Thickness
	Feet
St. Bede College	125
Cedar Point	139.8
Princeton	160
Matthiessen & Hegeler Zinc Co	132
Deer Park (Central farm)	125
Deer Park "A" (Strata inclined)	197
Deer Park "B" (70 feet exposed)	120
Deer Park (Northeast farm)	148
Deer Park (Dairy farm)	142

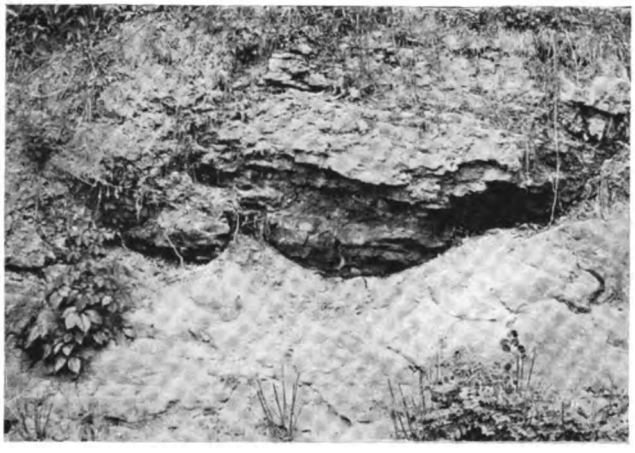

FIG. 12.—Unconformity between St. Peter sandstone and Platteville-Galena dolomite at Deer Park. Reproduced by permission of the University of Chicago Press.

The variation in the thickness of the St. Peter sandstone is due in the main to irregularities in the surface of the underlying Shakopee dolomite. The top of the sandstone may also have been somewhat eroded prior to the deposition of succeeding Platteville limestone, as is indicated by the unconformable relations between the two formations at Deer Park. (See Fig. 12).

The base of the formation is a foot or two of blue shale containing oolitic flints and fragments of porous silica weathered out of the underlying Shakopee

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FIG. 13.—Deer Park Canyon looking downstream. The cliffs are St. Peter sandstone. Photo by Rhodes.

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dolomite, and thought to represent the residual soil. Above this shale the lower 3 feet or so of the sandstone usually contains a large number of oolitic flints. The following section observed along Pecumsaugan Creek includes the zone of contact with the limestone.

Character of strata at the base of the St. Peter sandstone and the top of the Shakopee dolomite along Pecumsaugan Creek

Formation and bed	Thickness		Depth	
	Feet	*Inches*	*Feet*	*Inches*
St. Peter sandstone:				
Sandstone or sand	..	..	..	..
Clay, soft, blue	1	..	1	..
Sandstone with flints	2	..	3	..
Sand, brown to white	..	9	3	9
Clay, flints and yellow sand	1	6	5	3
Flints and clay, yellow, weathered	..	4	5	7
Sandstone, flinty	..	1	5	8
Clay, blue, oolitic	..	1	5	9
Clay, blue, fine; hard at base	1	2	6	11
Sandstone, flinty, white; oolitic interbedded with hard blue clay not oolitic	..	6	7	5
Flint	..	7	8	..
Sand, oolitic, and blue clay; in four alternating beds	..	6	8	6
Limestone, white; some hard white to blue clay and flints	..	8	9	2
Chert layer, oolitic	..	4	9	6
Clay, oolitic, bluish to buff; lenticular, few inches	..	..	..	..
Shakopee dolomite:				
Limestone; surface irregular; rock has weathered appearance	..	..	..	..

Along Tomahawk Creek near the NW. cor. sec. 35, Dimmick Township (T. 34 N., R. 1 E.), an outcrop at the contact of the two formations shows a zone of about 1½ feet composed of yellow sand and very oolitic blue clay throughout which oolitic flints are scattered. Above is the usual white sandstone.

Above the basal flint-bearing portion, the St. Peter formation is practically pure white, quartz sandstone, the proportion of silica being very high, at some places exceeding 99 per cent. In places the sand is so poorly cemented that the rock crumbles readily; but commonly the sandstone is marked by steep cliffs along sides of valleys (fig. 13).

STRATIGRAPHIC RELATIONS

The stratigraphic relation of the St. Peter sandstone with the underlying formation has been described. The contact with the overlying Platteville formation varies from an erosional unconformity to an apparent conformity. Usually the contact between the two formations is marked by a thin bed of shale, not over a few inches thick in exposures, but reaching four or five feet, as recorded by drillers. In the vicinity of Troy Grove, however, this shale

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is absent, and there is a gradual transition within about a foot from very sandy limestone resting on sandstone to the typical lower buff beds of the Platteville. There is, however, no gradual change from sandstone to limestone, the transition being confined to the overlying stratum.

A contact at Deer Park, well shown on the west side of the canyon at the end of the bridge at the lower falls (fig. 12), indicates an erosional unconformity between the two formations. The surface of the sandstone has a relief of about 2 feet, the limestone filling the hollows and overriding the ridges.

FOSSILS AND CORRELATION

The St. Peter sandstone can be regarded as practically a nonfossiliferous formation, though a few casts, mainly of pelecypods, have been reported from it in other regions. This formation is widespread in the central Mississippi Valley and is commonly correlated on the basis of its uniform lithological character, and its stratigraphic relations.

PLATTEVILLE AND GALENA FORMATIONS

NAMES AND RELATIONS

Upon the St. Peter sandstone rests the Platteville formation of dolomite and limestone, which in this region is commonly spoken of as the "Trenton." It is thought to be the equivalent of the Platteville formation of southwestern Wisconsin, which is well exposed in the vicinity of Platteville. Overlying the Platteville and generally conformable upon it is the Galena dolomite. This latter formation was named from the lead ore (galena) which it contains in certain localities and from its typical exposure at Galena, Illinois. Because of the similarity in the two formations and the difficulty of separating them in this region they have been mapped and will be described as one formation.

THICKNESS

The total thickness of the Platteville and Galena formations where drilling has penetrated the entire thickness is shown in the accompanying table.

Thickness of the Platteville and Galena formations in the Hennepin and La Salle quadrangles

	Thickness *Feet*
St. Bede College	325
Matthiessen & Hegeler Zinc Co	370
Chicago Portland Cement Co	385
Illinois Zinc Co	350
City of Peru	360
Cedar Point	390
Princeton	335

The variations in thickness shown in the table probably arise from the occurrence of limestone in the lower part of the overlying Maquoketa forma-

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tion which is difficult to distinguish from the Galena in drilling. There are also unconformities between underlying formations.

DESCRIPTION AND SUBDIVISIONS

The Platteville-Galena formations are known from drill records, well samples, and outcrops. Along and east of the anticline the formations are known from outcrop and from drill records while west of the fold the rocks are known only from drilling. A section of the Platteville-Galena formations recorded from driller's samples is presented in the compiled section given near the beginning of this chapter.

The Platteville-Galena formations in this region in some places show lithologic characteristics similar to those in the sections observed in Wisconsin. The formations in Wisconsin are generally divisable into three parts, a massive chert-bearing dolomite above and below, and an intermediate thinner series of thin-bedded compact and fossiliferous limestone. The limestone begins near the contact of the two formations, usually slightly above it, and extends downward. In the Oglesby well the hard, bluish-gray limestone found at a depth of 1,425 to 1,430 (see compiled section noted above), resembles very much the bluish limestone commonly found near the junction of the formations in Wisconsin. Similar lithologic changes were not noted in the sample from a well at Cedar Point, but a well at Depue shows rather definitely the three-fold division. As is indicated on the areal geology map, these formations are exposed in limited areas only, and the rock displays such varied lithologic character from place to place that no typical section can be given. In general, however, the two dolomitic and one intermediate limestone series are recognizable.

Along Little Vermilion River in the vicinity of Troy Grove and north one-half to three-quarters of a mile the rock is a flat-lying, buff, flinty dolomite, part of the lower buff beds of the Platteville formation. No more than 15 feet of the formation are exposed. The beds immediately overlie the St. Peter sandstone, the latter formation being found in contact with the dolomite in the NW. ¼ SE. ¼ sec. 35, Troy Grove Township (T. 35 N., R. 1 E.), on the east side of Vermilion River.

In the N. ½ sec. 27 and the SW. ¼ sec. 22, Dimmick Township (T. 34 N., R. 1 E.), the Platteville is exposed lying between the "Coal Measures" and the St. Peter sandstone. The limestone is also exposed along the anticline at Split Rock and along the east bank of the Vermilion and at the mouths of the tributary valleys near Deer Park in secs. 30 and 31, Deer Park Township (T. 33 N., R. 2 E.), in the bed of Vermilion River and along the ravine in the N. ½ sec. 5, Vermilion Township (T. 32 N., R. 2 E.), and along Vermilion River in the E. ½ sec. 8 and in sec. 9, of the same township, near Lowell. Dolomite or magnesian limestone similar to that found at Troy Grove

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is found along Deer Park Glen east of the axis of the fold. The rock found above the sandstone in the clay pits south of Utica though probably containing a high percentage of magnesia is not buff in color nor porous in texture as the dolomite is elsewhere. At the mouth of Deer Park Canyon near the contact with the St. Peter sandstone there is an old quarry showing about 10 feet of heavy-bedded and flint-bearing rock that is somewhat dolomitic. Along Vermilion River in the NE. cor. sec. 31, Deer Park Township (T. 33 N., R. 2 E.), north of the mouth of Deer Park Canyon, thin-bedded, bluish-gray, hard limestone is exposed dipping into the stream at an angle of 33

FIG. 14.—Galena-Platteville thin-bedded limestone exposed in Clayton's Ravine in the NE. ¼ sec. 31, Deer Park Township.

degrees (fig. 14). The dip decreases to the east, the heavy flint-bearing beds noted above dipping 22 degrees west.

Along Hollinger Branch in the N. ½ sec. 5, Vermilion Township (T. 32 N., R. 2 E.), the Platteville-Galena outcrops for nearly one-half mile. The strata vary from a thin-bedded, mottled limestone at the west and above to bluish, dense, hard, limestone breaking with conchoidal fracture to the east and below. These latter beds resemble beds in the upper part of the Platteville in the Wisconsin region. The dip of the beds along this valley varies

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from 2 degrees at the east to 10 degrees at the west. The thickness exposed at any one place does not exceed 10 feet, and the total thickness is not over 35 to 40 feet.

The most extensive exposure of the formation occurs along the banks and in the channel of Vermilion River near Lowell. Here the limestone dips S. 35° W. at an angle of 7 degrees, and outcrops continuously from between one-half and three-quarters of a mile above Lowell bridge to about one-quarter of a mile below the bridge. The rock is brown to gray, mottled limestone and dolomite and resembles the strata exposed at Split Rock and Deer Park.

FOSSILS AND CORRELATION

Small collections of fossils have been made from various outcrops of the Platteville and Galena limestones and dolomites. These have been identified by Prof. T. E. Savage.

Fossils from the Platteville-Galena formations

	1	2	3	4	5
Receptaculites oweni Hall	..	..	X	..	..
Lingula near cobourgensis	..	X	..	..	..
Orthis tricenaria Conrad	X	..	..	X	..
Platystrophia biforata Schlotheim	..	..	X	..	..
Dalmanella subaequata var	..	X	..	..	..
Dalmanella testudinaria Dalman	..	X	X	X	X
Plectambonites sericea Sowerby	..	..	X	..	..
Rafinesquina alternata Conrad	X	X	..	..	X
Rafinesquina minnesotensis N. H. Winchell	..	..	X	X	..
Strophomena incurvata Shepard	..	X	..	..	..
Strophomena cf trentonensis	..	..	..	..	X
Ctenodonta alta Hall	..	..	..	X	..
Ctenodonta gibberula Salter	..	..	..	X	..
Endodesma sp	..	..	..	..	X
Cyclospira bisulcata Emmons	..	X	..	..	..
Scenella cf. affinis	..	..	..	X	..
Scenella cf. compressa	..	..	..	X	..
Bellerophon sp	..	..	..	X	X
Tetranota sp	..	X	..	..	..
Hormotoma gracilis Hall	..	..	..	..	X
Lophospira sp	..	X	..	X	..
Trochonema cf. beachi	..	..	..	..	X
Trochonema sp	..	..	X	X	..
Raphistoma lenticulare Emmons	..	..	..	..	X
Illaenus sp	X	..	..	..	..

1. From dense bluish limestone near base of section in ravine in N. ½ sec. 5, Vermilion Township (T. 32 N., R. 2 E.)
2. Clayton's Ravine in the NE. ¼ NE. ¼ sec. 31, Vermilion Township (T. 32 N., R. 2 E.)
3. Near Lowell bridge over the Big Vermilion.
4. Gully in the NE. ¼ NW. ¼ sec. 27, Dimmick Township (T. 34 N., R. 1 E.)
5. Along Little Vermilion River in the SE. ¼ NE. ¼ sec. 27, Dimmick Township (T. 34 N., R. 1 E.)

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The fossils listed above are common to strata of middle Ordovician age, and such horizons as contain *Receptaculites* can be definitely assigned to the Galena. Other forms common in the Galena dolomite of Wisconsin are *Orthis tricenaria, Dalmanella testudinaria, Plectambonites sericea,* certain varieties of *Rafinesquina alternata,* and *Strophomena incurvata.*

No definite faunal evidence for the correlation of any of the exposures with the Platteville can be cited. It is thought, however, that the beds overlying the St. Peter sandstone, as at Deer Park, including the heavy, flinty beds at the base and the thin-bedded, fossiliferous beds above are probably of Platteville age.

The upper and middle parts of the Platteville are commonly correlated with the Lowville formation of New York and the lower part, known in places as the "Lower Buff Beds," are thought to be of the same age as the upper

FIG. 15.—The irregular surface of Galena-Platteville limestone upon which was deposited the Pottsville clay, as exposed in the bottom of an abandoned clay pit in section 15, Vermilion Township.

part of the Stones River group of Tennessee. The Galena formation is about the same age as the Trenton limestone of New York, but includes at the base beds of upper Black River age.

STRATIGRAPHIC RELATIONS

The stratigraphic relations with the underlying St. Peter sandstone have already been described.

The unconformity at the top of the Galena dolomite is, in the area of exposed rocks, unquestionable. Wherever the Galena is overlain by younger rocks, the exposed record indicates a great lapse of time and in most places angular superposition. The Pennsylvanian sediments either lie upon the

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roughly truncated edges of the Galena-Platteville as at Split Rock, Deer Park, and Lowell, or fill in the hollows of the eroded irregular surface of the flat-lying strata as at the clay pits south of Utica (fig. 15).

West of the fold, where the Galena-Platteville group is known only from drilling and where the Galena is overlain by probably the next youngest Ordovician strata in northern Illinois, namely the Maquoketa, the nature of the contact is unknown. That this contact may be marked by a discordance is suggested from the relationships observed elsewhere in the State and by variations in the thickness of the Galena-Platteville noted in the deep wells of this area.

UPPER ORDOVICIAN SERIES

MAQUOKETA FORMATION

NAME AND DISTRIBUTION

Upon the Galena dolomite in the area west of the fold lies a shale, or shale and limestone, formation thought to be the Maquoketa formation, a name derived from the Little Maquoketa River in Iowa on which these strata are typically exposed. The same formation has been known in the older Wisconsin and Illinois reports as the Cincinnati shale. In these quadrangles the formation is known only from drilling samples and from records of deep wells. It is thought to be everywhere overlain in this area by the Niagaran dolomite, except possibly in the northwest corner of Westfield Township (T. 17 N., R. 11 E.) and the southwest corner of Troy Grove Township (T. 35 N. R. 1 E.), where a few farm wells pass through a thick blue shale before reaching a dolomite, probably Galena. This area is included in that indicated as undeterminable Ordovician on the Structural and Economic geology sheet. (See Plate II in pocket.)

THICKNESS AND CHARACTER

The records of several deep wells show thicknesses of the Maquoketa as tabulated below.

Thickness of Maquoketa formation in various wells in the Hennepin and La Salle quadrangles

	Feet
Chicago Portland Cement Co. (Oglesby)	190
Western Clock Co. (Peru)	182
Matthiessen & Hegeler Zinc Co. (La Salle)	180
Peru Beer Co. (Peru)	180
Illinois Zinc Co. (Peru)	178
St. Bede College (Spring Valley)	240(?)
Cedar Point (Mine No. 5)	145
Mineral Point Zinc Co. (Depue)	170
Princeton	175

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It seems probable that the Maquoketa in this region is from 175 to 190 feet thick. At Cedar Point the lower part of the formation is limestone, and therefore the position of the contact of the Maquoketa and the Galena could not be determined with certainty. If 40 feet of the upper part of the strata assigned to the Galena should be assigned to the Maquoketa, each formation would have about the average thickness characteristic of the area. It seems probable, likewise, that the contact of the two formations in the St. Bede well was placed too low on the basis of the driller's record, since the Maquoketa is thicker and the Galena-Platteville thinner than the average. The Maquoketa varies in its lithologic character from shale to limestone. The shale occurs at the top of the formation and commonly at the bottom. The limestone when found commonly exists as one or two ledges near the middle of the formation. Probably in some places limestone is found at the base of the Maquoketa overlying the Galena dolomite. Descriptions of the Maquoketa strata encountered in one well in the quadrangle based on the examination of driller's samples are presented in the compiled section given near the beginning of this chapter.

CORRELATION AND STRATIGRAPHIC RELATIONS

Except for its stratigraphic position between the underlying Galena and the overlying Niagaran formations there are no data upon which to base the identification of the Maquoketa shale in this region. But as this is the relation that exists generally wherever the Maquoketa outcrops in northern Illinois the correlation is thought to be correct.

The Maquoketa formation of northern Illinois and neighboring parts of Wisconsin and Iowa is of Richmond age, having been deposited in the upper part of the Cincinnatian or Upper Ordovician epoch. So far as known there are no deposits of Lower or Middle Cincinnatian time in this region. An unconformity is widespread below the Richmond in the Mississippi Valley.

Upon the Maquoketa shale and limestone lies a dolomite thought to be the Niagaran. The contact between the two formations has been shown[1] to be unconformable in Kankakee and Will counties to the east of the anticline. Data are lacking to the west, but the general prevalence of this unconformity in Illinois, Wisconsin, and Iowa makes it probable that it also exists in this area.

SILURIAN AND DEVONIAN (?) SYSTEMS

THICKNESS AND LITHOLOGIC CHARACTER

Between the rocks believed to be of Carboniferous age and those of Ordovician age is a thick series of dolomite and greenish-gray, siliceous, dolomitic limestone, or hard calcareous shale 400 to 490 feet thick, the lower part of

[1] Savage, T. E., Stratigraphy and paleontology of the Alexandrian series in Illinois and Missouri: Illinois State Geological Survey Bull. 23, p. 92. 1913.

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which is probably of Niagaran age. These rocks are known only from drilling records and driller's samples.

The following table shows the thickness of the limestone and dolomite lying between the Maquoketa shale and the strata of probable Pennsylvanian age, as shown by drilling at various places in the quadrangles:

Thickness of strata thought to be Silurian or Devonian in the Hennepin and La Salle quadrangles

	Thickness *Feet*
Western Clock Co. (Peru)	393
Peru Beer Co. (Peru)	400
Matthiessen & Hegeler Zinc Co. (La Salle)	365
Cedar Point	305
Chicago Portland Cement Co	405
St. Bede College (Spring Valley)	460
Depue	479
Princeton	335

The differences in the thickness of these strata are believed to be due to pre-Pennsylvanian erosion.

From the various drilling records and drilling samples a two-fold lithologic division of this heavy series of dolomite is apparent. The lower part of the series is a white or straw-colored dolomite that is very hard and resembles the Niagaran dolomite outcropping in the vicinity of Joliet and Chicago. This part of the section has a thickness of about 225 feet, not varying from this more than 25 feet. The upper part of the section is composed of a dense, siliceous, impure limestone, possibly a hard shale, of a greenish-gray color and, apparently at least in some of the wells, containing beds of grayish shale, resembling the fire clay below the La Salle (No. 2) coal at Utica or Lowell. These strata have been variously identified as of Niagaran, Devonian, and Pennsylvanian age, but so far as known they offer no evidence for accurate determination, and lithologically they differ, except for the associated shales, from the outcropping rocks of any of the systems with which they have been identified.

Carboniferous System

Pennsylvanian series

General statement

Pennsylvanian sedimentary rocks rest unconformably upon the limestones, shales, and sandstones of possible Devonian (?) and of Silurian and Ordovician age. Successively younger rocks underlie the Pennsylvanian strata in passing from east to west across the quadrangles. Where the contacts are exposed the Pennsylvanian rocks overlie Ordovician rocks—either the St. Peter sandstone or Galena-Platteville limestone and dolomite. Information relative to the unexposed contacts has been obtained from deep drilling. The

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Pennsylvanian rocks underlie the glacial drift over the entire area except portions of the La Salle quadrangle on the north side of Illinois River east of a line connecting Dimmick (sec. 4, T. 34 N., R. 1 E.), and Split Rock (sec. 13, T. 33 N., R. 1 E.). It is possible that pre-glacial erosion may have cut through the Pennsylvanian strata along the line of the Rock-Illinois Valley in the vicinity of Princeton.

SUBDIVISIONS

The Illinois Pennsylvanian or "Coal Measures" rocks are divided into three formations all of which are represented in the Hennepin and La Salle quadrangles. In ascending order these are the Pottsville, Carbondale, and McLeansboro formations. In southern Illinois where the section is more complete and thicker these formations are more characteristically developed, and the horizons of separation are definite. In this area the Pottsville is distinct as elsewhere, but the boundary between the Carbondale and the McLeansboro is not so definite. These formations, correspond, in part at least, to the Pottsville, the Allegheny and Conemaugh formations, respectively, of Pennsylvania.

POTTSVILLE

Thickness and lithology of the Pottsville between Bureau and Oglesby.—There is some difficulty in determining the boundary between the Pennsylvanian and pre-Pennsylvanian rocks in this part of the area because of the character of the underlying rocks, which have been included in the description of the strata of the Silurian and Devonian systems. As has been said this part of the section has been variously interpreted as of Pottsville, Devonian, and Silurian age and there seems to be no means of definitely determining its age at present. It is thought that possibly the Pottsville sediments extend down only to the top of a series of strata which are predominantly dense, somewhat calcareous and siliceous, greenish-gray and reddish shale or impure limestone. The nature of the strata is exceedingly difficult to determine with confidence because the samples of the harder rock are commonly mixed with fragments of soft shale resembling fire clay of Pennsylvanian age. On the basis of these identifications the following thicknesses of the Pottsville have been noted:

Thickness of the Pottsville formation in wells in the Hennepin and La Salle quadrangles

	Thickness *Feet*
Chicago Portland Cement Co. (Oglesby)	75
Matthiessen & Hegeler Zinc Co. (La Salle)	70
Western Clock Co. (Peru)	64
Peru Beer Co. (Peru)	78
Mine No. 5 (Cedar Point)	185
St. Bede College (Spring Valley) about	50±(?)
Mineral Point Zinc Co. (Depue) between 106 and	78

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The following descriptions of the drilling samples show the character of the Pottsville formation in the vicinity of La Salle:

Description of the drill cuttings from the base of the La Salle (No. 2) coal into the known Niagaran dolomite in the well of the Matthiessen & Hegeler Zinc Co., at La Salle

Surface elevation 585 feet

Description	Thickness	Depth
	Feet	*Feet*
Elevation of the La Salle (No. 2) coal about 90 feet above sea level.		
Shale, dark gray, rather dirty	5	500
Shale, dark gray, and pieces of hard, greenish shale	5	505
Shale, dark gray, slightly calcareous	5	510
Shale, light gray, siliceous; pieces of hard, dark shale	5	515
Shale, gray; quartz sand; sandstone; black "slate"	5	520
Sandstone, fine, light gray	6	526
Sandstone; gray shale; gray fire clay; greenish shale	6	532
Coal; sandy gray shale, dark carbonaceous clay, like fire clay	6	538
Shale, gray, siliceous; dark, brownish-gray clay, like fire clay, with smooth surfaces	5	543
Clay, brownish gray, structureless; fine sandstone or siliceous shale	7	550
Same as above; clay more siliceous	5	555
Coal, large fragment; black carbonaceous shale; clay, dark gray	5	560
Shale, black, carbonaceous; fine sandstone or siliceous shale, light gray; floor clay-like shale	5	565
Shale or earthy dolomite; light greenish gray	5	570
Same	5	575
Same	5	580
Dolomite, grayish, dense	5	585
Dolomite, as above; pieces of dark clay shale breaking with smooth, irregular, sub-lustrous surfaces on broken floor clay of No. 2 coal	5	590
Dolomite, grayish green, dense, and a large lump of clay resembling floor clay, somewhat carbonaceous	5	595
Same as above but in fine pieces	5	600
Dolomite or shale, light greenish; shale, dark, earthy; little brown fissile shale	5	605
Same as above; with fragments of dark to black massive clay resembling floor clay	5	610
Shale, dark, fire clay-like shale with some hard, greenish-gray rock, possibly represents a bed of fire clay	5	615
Samples lost. Possibly base of Pennsylvanian between 615 and 630 feet.		
Dolomite, light, grayish green; clear rock with no shale differing in this respect from the preceding	5	635
Dolomite, grayish green with specks of pyrite	5	640
Dolomite, greenish gray; chips somewhat smaller than those above	5	645
Dolomite, like that above; with streaks of fine-grained, reddish sandstone	5	650
Dolomite, fine-grained, light greenish	5	655
Same	35	690
Same, with a few black fragments	5	695
Samples 695 to 720 lost		
Typical Niagaran probably begins between 695 and 720 feet	..	720
Dolomite, white and greenish, fine-grained	5	725
Dolomite, light greenish to cream colored	5	730
Sample lost	10	740
Dolomite, light cream colored	10	750
Same	10	760
Dolomite, very fine powder	10	770
Niagaran continued to	..	930

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A comparison of the different available records of the Pottsville west of the anticline indicates the presence in most of the artesian wells of two beds of coal, probably thin, the upper one 50 to 60 feet below the La Salle (No. 2) coal, and the other 20 to 30 feet lower. The rest of the section is mostly dark grayish, structureless clay resembling the Lowell pottery clay and the Utica clay of the Pottsville east of the anticline. There is commonly a sandy layer near the top and another near the bottom of the formation.

Pottsville formation along and east of the La Salle anticline.—The Pottsville formation on the east side of the anticline is of interest and of economic importance as a source of pottery clay and fire clay. It is best known from its outcrops in the La Salle quadrangle and in the Ottawa quadrangle to the east.

The exposures of the Pottsville are numerous both along and east of the fold, as shown on the geological map.

Stratigraphic sequence.—The stratigraphic sequence of the formation can be apparently correctly interpreted only from the succession found in the vicinity of Deer Park.

The following drilling record of a well located at the power house in Deer Park gives the most complete section of the Pottsville available and shows the relation of the formation to the underlying and overlying strata.

Driller's record of a well at the power house in Deer Park, in the SE. ¼ SE. ¼ sec. 30, Deer Park Township

Surface elevation about 625 feet above sea level.

Description of strata	Thickness	Depth
	Feet	*Feet*
1. Surface clay	12	12
2. Clay and limestone	3	15
3. Clay or shale, green	6	21
4. Clay, reddish	4	25
5. Clay, blue and black	4	29
6. "Slate" and black clay	3	32
7. Clay, hard, dark	1	33
8. Clay, dark, hard, mixed with chocolate-colored clay	8(½?)	41(½?)
9. Coal, not over 2½ feet	2½	44
10. Coal and clay	2	46
11. Clay	13	59
12. Coal	¼	59¼
13. Limestone	3	62¼
14. Clay	4¾	67
15. Clay, limestone and sulphur	1	68
16. Clay, white	7	75
17. Clay and sand	10	85
18. Limestone	10(12?)	97
19. White sandstone	91	188

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The sandstone, No. 19, in the preceding section is the St. Peter sandstone; the overlying limestone is the Platteville. The succession from No. 17 to the clay below the coal in No. 10 belongs to the Pottsville formation. The remainder of the section up to the surface clay belongs to the Carbondale formation. The surface clay is glacial or post-glacial. Commonly there is found at Deer Park a sandstone occupying the position of part of or all of the clays, number 14, 15, and 16. Limestone No. 13 where seen in outcrop commonly has a pisolitic structure and is not uncommonly underlain by sandstone possibly the "limestone" in No. 16.

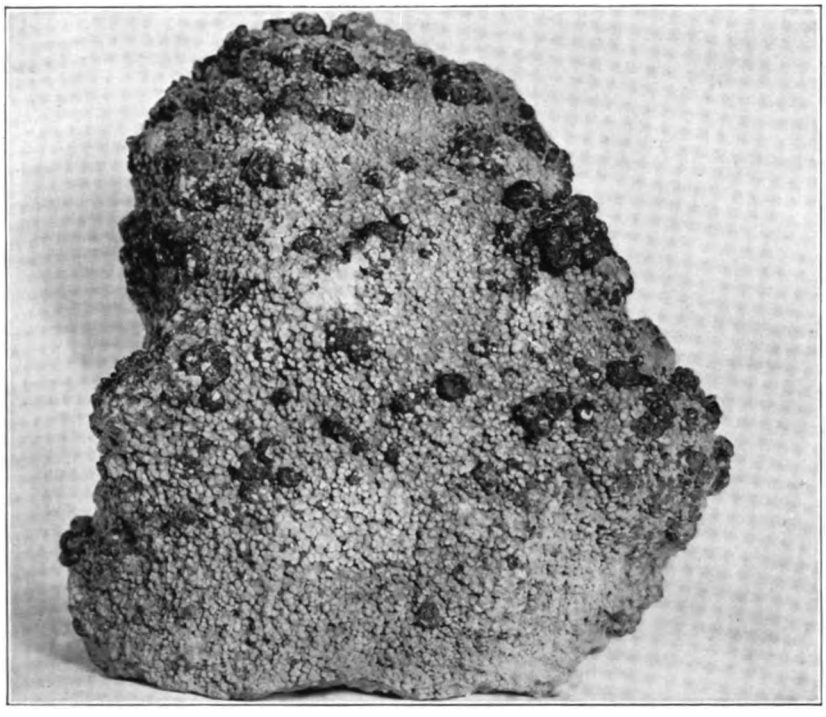

FIG. 16.—Boulder of pisolitic limestone from the Pottsville formation of southwestern Illinois. Similar to boulders found in the Starved Rock region. Reproduced by permission of the University of Chicago Press.

The stratigraphic section as described in the preceding paragraphs holds in general for the Deer Park region. The succession at other places varies, as has been stated, with the omission or better development of one or more of the strata present at Deer Park.

At Lowell the Pottsville is represented almost entirely by clay, locally known as the Lowell pottery clay. The sections at Lowell vary in their succession from the typical section at Deer Park mainly in the absence of the

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sandstone commonly found along the Deer Park Glen and located stratigraphically below the pisolitic limestone boulders. It is possible that the siliceous limestone at the "mill" pit may be the equivalent of this sandstone. It is believed that the source of this sandstone is the St. Peter sandstone and that the stratum will naturally become of less importance toward the south farther from the outcrops of the St. Peter sandstone in Pottsville time.

The succession in the clay pits south of Utica in secs. 20 and 31, Deer Park Township (T. 33 N., R. 2 E.), is essentially the same as the succession at Lowell. The clay here is in places as much as 20 feet thick and overlies an irregular surface of grayish-white, very dense flinty, dolomitic limestone, probably of Platteville age.

Lithologic character.—The general lithologic character of the Pottsville has been described in the preceding section. A few of the beds, and only those that outcrop, are sufficiently well known to warrant especial description. These are the pisolitic limestone, the ferruginous sandstone, and the lower clays.

The pisolitic limestone (fig. 16) is a grayish rock found in this region only in isolated boulders rarely over a foot in diameter, or in one locality, at least, as a coating over the Platteville dolomite. Commonly the boulders are surrounded by limestone possessing a cone-in-cone structure to a thickness of 3 or 4 inches.

Especial significance is attached to the finding of pisolitic limestone at this horizon because it characterizes the same horizon at many other places in the western part of the State as far south as St. Louis. It is regarded as lying at or near the top of the Pottsville group in this State.

The sandstone lying a short distance below the horizon of the pisolitic limestone was apparently derived from the St. Peter sandstone. The constituent particles are well-rounded, coarse quartz grains similar to those of the St. Peter and the stratum to the north and northeast grades into, and merges with, the upper part of the older sandstone. The especial difference between the two rocks is the very ferruginous character of the younger, it being impregnated with iron in various stages of oxidation and with some iron sulphide. The sandstone is very irregular in thickness both upper and lower surfaces being uneven. The upper surface is pitted and knobby in turn.

The clays of the Pottsville are commonly structureless, dark to light-gray clays, the upper part of which is somewhat darker than the lower and contains more iron and sulphur. Where weathered the clays have a yellow color and a more porous texture but are, nevertheless, more plastic. Near the base, especially in the Utica pits, the clay contains flints apparently derived from the flinty dolomite upon which the clay rests (fig. 17). About 6 feet below the coal in the Utica pits there is commonly a streak of greenish clay less than a foot in thickness. The clay is fine grained and even in texture where it overlies limestone; farther east on the Ottawa quadrangle where the clay lies

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upon St. Peter sandstone, grains of white quartz sand are scattered through it. The character of the Lowell clays and their relation to the underlying rock suggest that they are largely residual deposits from the decay of the underlying rock.

Correlation.—The correlation of the clays of the Pottsville formation is based upon a statement made by David White:[1] "It may be interesting to note * * * * that the clays worked at Utica on the northern rim of the basin belong to the Cheltenham horizon and that their stratigraphic relations to No. 2 coal are nearly identical with those exhibited at East Alton or near St.

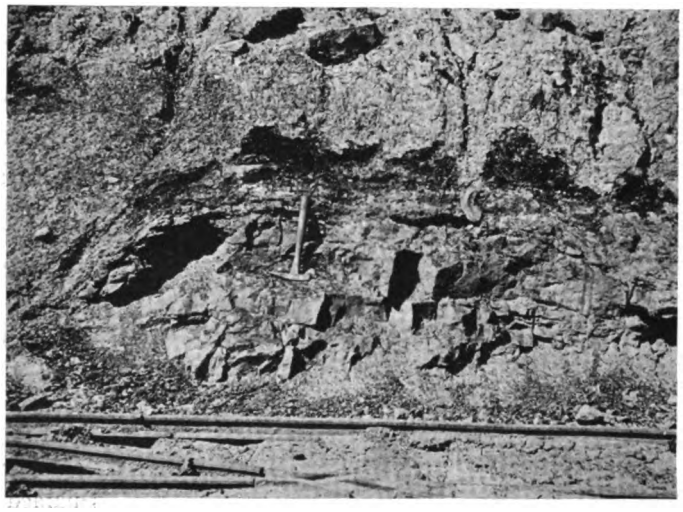

FIG. 17.—Pottsville clays overlying the Platteville-Galena dolomite in a clay pit west of Starved Rock Park. Shows the irregularity of the surface of the dolomite. Reproduced by permission of the University of Chicago Press.

James, though at Utica the fire clays repose directly either upon the St. Peter sandstone or on residual bosses of a limestone for which a comparison with the Platteville has been suggested."

The preceding statements on the correlation of the Pottsville formation are based upon investigation by Mr. White several years before the field work on these quadrangles was undertaken and definite information in regard to the horizons from which the fossils were collected is not available so that the conclusions apply to the body of clays below No. 2 coal and probably to the upper rather than to the lower part of these clays.

The Utica clay is thought to be the same age as the Cheltenham which is placed by White[2] near the horizon of the Mercer group in the upper Pottsville of western Pennsylvania.

[1] Illinois State Geol. Survey Bull. 14, p. 294, 1909.
[2] Illinois State Geological Survey Bull. 8, p. 268, 1907.

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CARBONDALE FORMATION

General features.—The Carbondale formation is typically exposed near Carbondale in southern Illinois and extends from the base of the Murphysboro (No. 2) coal to the top of the Herrin (Belleville, No. 6) coal. Definite upper limit to this formation in the Hennepin-La Salle region is lacking as the Herrin (No. 6) coal is probably not present, but the approximate boundary is assumed to lie about midway between the Harrisburg (No. 5) coal and the Streator (No. 7) coal at the base of an extensive sandstone bed. The base of the formation is as elsewhere regarded as the base of La Salle (No. 2) coal.

The Carbondale formation underlies that part of the area lying within the outcrop of the La Salle (No. 2) coal, as shown on the areal geology sheet. (See Plate II in pocket.)

The thickness of the formation is uncertain because of indefiniteness in regard to the position of the top of the formation. If the top of the Carbondale formation lies about midway between the two upper coals, the average thickness of the Carbondale is about 196 feet. The variations in thickness are from about 125 feet along the fold in the vicinity of Deer Park to 220 feet within about one mile of the fold along the Illinois Valley and in the vicinity of Cedar Point.

There are in general two types of deposits in the Carbondale formation. The lower one-half of the section is a succession of thin limestones, calcareous shales, black fissile shales, and coal beds. The upper half of the section is sandstone and sandy, micaceous shale including midway in the series an irregular bed of coal underlain by clay and overlain by dark shale.

La Salle (No. 2) coal.—The La Salle (No. 2) coal is named from the city of La Salle where this bed is the principal bed worked. It is the lowest workable coal in the north-central part of the State, and because of the long-wall method of working the bed the field is called the Longwall District.

The La Salle (No. 2) coal has been correlated by David White[1] with the Murphysboro (No. 2) coal. "The fossil plants collected from the mines at Murphysboro, Colchester, and Minonk, and from the 'Third Vein' near La Salle appear on preliminary examination to accord so well with the flora overlying the Wilmington coal at Morris and Braidwood as essentially to confirm the generally accepted reference of these coals to the same horizon; that is, to No. 2 coal. * * * * As stated last year No. 2 coal is, in my judgment, to be regarded as lying very near the boundary between the Pottsville and the Allegheny, though distinctly Allegheny in age."

La Salle (No. 2) coal has been found within the area bounded by its line of outcrop wherever the drill has penetrated to sufficient depth. Its regularity in thickness and physical characteristics and the similarity of the asso-

[1] Illinois State Geological Survey Bull. 14, p. 293, 1909.

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ciated strata over wide areas renders it easy of identification from place to place both at outcrops and in drill holes.

The average thickness of the coal in the La Salle region west of the anticline is between 36 and 42 inches. In the southwest quarter of the Hennepin quadrangle the coal is about 1 foot thinner than the general average. The coal bed is thinner than average also east of the fold, especially toward the north along Illinois River, where in the clay pits south of Utica it is about 2 feet thick. In the vicinity of Lowell it is about 6 inches thicker than along the Illinois.

La Salle (No. 2) coal is a long-grain coal, splitting most readily parallel to the bedding, and having poorly developed cleat. The coal is relatively hard but brittle, the top coal being harder than that below, where there is any difference.

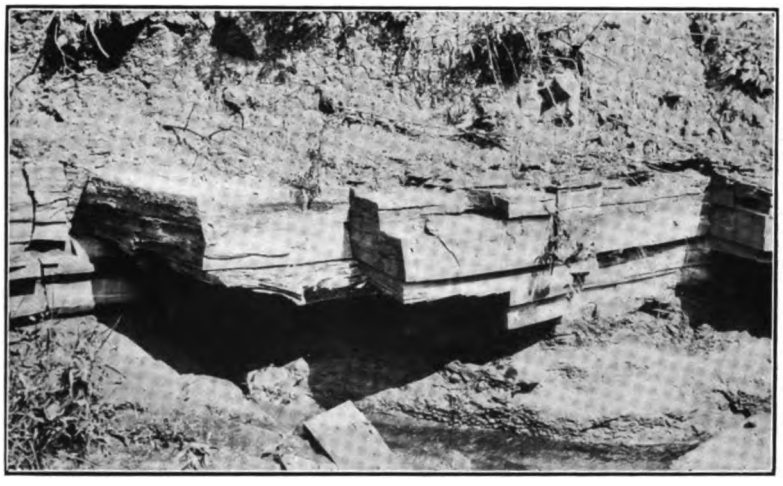

FIG. 18.—Black fissile shale or "slate" 15 to 18 feet above the La Salle (No. 2) coal. Reproduced by permission of the University of Chicago Press.

The bed is made up of dull coal interlaminated with thin layers of bright glance coal. Here and there are layers, lenses, or balls of sulphur (pyrite or marcasite), mother coal, and dirt. The bedded impurities do not make up a large percentage of the coal and they are not localized at any definite horizon in the bed. In the La Salle region this is the cleanest of the three coal beds that are of economic value.

Irregularities known as *rolls* are found from place to place. These are in some places faults, and elsewhere a replacement of the upper part of the coal by clay or shale, the roof apparently rolling down into the coal bed. Such rolls are common, though not sufficiently common to present any great obstacle to mining. At places along Vermilion River masses of calcareous rock inter-

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rupt the continuity of the coal bed, but the distribution of the irregularity is local.

Strata between La Salle coal and Vermilionville sandstone.—The roof shale above the La Salle (No. 2) coal is a gray, commonly bedded shale, containing small nodules of ironstone. The shale is variable in thickness. It is reported to extend 50 feet above the coal in the La Salle mine, and not uncommonly in other places is entirely lacking, the black fissile shale resting upon the coal. The average thickness of the shale is about 18 to 20 feet.

The black shale overlying the roof "soapstone" is 30 to 36 inches thick and has a fissile structure (fig. 18). It is characterized by numerous ironstone concretions, in some places making up the bulk of the stratum, and known in miners' parlance as "niggerheads" (fig. 19). They have been seen as great as 6 feet in diameter.

FIG. 19.—Ironstone concretions or "niggerheads" in the black fissile shale above the La Salle (No. 2) coal, SW. ¼ sec. 9, Vermilion Township.

Immediately above the black fissile shale there follows a gray shale about 4 feet thick in which are many *septarian* concretions. These nodules possess a peculiar structure due to intersecting planes of calcite and have a weathered surface that resembles the shell of a turtle. So far as known, this is the only horizon in this area where such septarian concretions are found, and they afford a rough, but apparently reliable, means of identification of the stratum.

The section from the septarian shale to the Vermilionville sandstone is composed of a series of gray and dark shales and limestones, terminating above in a brownish, siliceous and micaceous shale of variable thickness up to 50 feet. These strata are well exposed near Lowell on Big Vermilion River where the following section was measured:

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Section of part of the Carbondale formation along Big Vermilion River near Lowell

Beds	Thickness	Depth
	Feet	*Feet*
Sandstone (Vermilionville)	25	25
Shale, brown, siliceous, micaceous	0–15	40
Shale, black, sheety	2	42
Shale, green, blue, and gray	3	45
Limestone, impure, fossiliferous	1½	46½
Shale, hard, gray	1	47½
Shale, hard, calcareous and carbonaceous, breaks in squarish fragments	3¼	50¾
Shale, carbonaceous; almost cannel coal	¾	51½
Shale, black	4½	56
Shale, bluish and greenish	12	68
Limestone, impure, argillaceous and sandy	2½	70½
Shale, grayish blue, plastic	15	85½

Strata from the Vermilionville sandstone to the bottom of Springfield (Harrisburg or No. 5) coal.—The Vermilionville sandstone is named from the village of Vermilionville, Deer Park Township, near which it is typically exposed. The sandstone outcrops along the "Big Bend" of Vermilion River in the NW. ¼ sec. 5, Vermilion Township, and thence discontinuously southward along the Vermilion nearly to Streator. The sandstone is thicker and more persistent beyond the limits of the quadrangles than within them.

This sandstone formation is composed of micaceous sand containing much white mica and blotches and streaks of carbonaceous material. The rock is massive or heavy bedded and finer and better cemented than the St. Peter sandstone. Perpendicular faces are preserved along cliffs because the rock tends to break off in large blocks parallel to the face of the cliff.

According to Freeman[1] this sandstone varies in thickness to a maximum of 35 feet. The thickest observed section of the member in this area is along Vermilion River at the "Big Bend" near the NW. cor. sec. 5, Vermilion Township. Here the sandstone is about 25 feet thick and above it is very sandy shale into which it grades. The shale has a thickness of about 35 feet.

The distribution of the sandstone along the outcrop has been described. The drill records show that this sandstone is generally lacking north of the Illinois, but it attains greater and greater thickness to the southeast. The drill records rarely show any sandstone at this horizon, but sandy shale is very thick. There may possibly be 34 feet of sandstone present at Spring Valley, but such a thickness is unusual this far north. A record of the shaft at Taft shows 12 feet of sandstone; at Cedar Point there are 101 feet. This sandstone member in general seems to be best developed along the southwest side of the anticline beyond the limits of the quadrangles. Where the sandstone is absent

[1] Freeman, H. C., La Salle County: Geological Survey of Illinois, Vol. III, Chap. XIV, pp. 264-266, 1868.

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its place is taken by brown, micaceous shales, similar to those previously described as underlying the sandstone.

Upon the brown shale or the Vermilionville sandstone rests the floor clay of the Springfield (No. 5 or "Second Vein") coal. The greatest observed thickness of this clay was 8 to 10 feet along Vermilion River.

Springfield (No. 5) coal.—The Springfield (No. 5) coal is so named from its occurrence in the Springfield region, where it is the principal coal mined. The same coal is mined on a large scale near Harrisburg in Saline County and in that part of the State is known as the Harrisburg coal. The first Geological Survey of Illinois named this coal bed No. 5, and it is locally known in the La Salle region as the "Second Vein" coal.

The correlation of the coal is based solely upon physical characteristics, the criteria for paleontological correlation not being known. The fact that the coal has a black "slate" or fissile shale roof and that it is characterized by "horsebacks"—clay-filled cracks crossing the bed more or less vertically—have led to the correlation. In two of the mines in Bureau County a thin clay band near the bottom of the coal is suggestive of the "blue band" commonly found in the Herrin (Belleville, No. 6) coal. In general, however, the coal and associated strata are more suggestive of the Springfield than the Belleville coal. Definite correlation must wait upon paleontologic evidence not available at present, though more extensive drilling from Springfield northward would be of great assistance.

The thickness of the Springfield (No. 5) coal based upon 50 drill records from the two quadrangles varies up to 72 inches. The average thickness is 43½ inches; within the area of the quadrangle the average thickness in Putnam County is 37 inches, in La Salle County 36 inches, and in Bureau County 49 inches.

The Springfield (No. 5) coal is not found east of the area affected by the fold within the La Salle quadrangle. Its distribution to the west is irregular due to failure of deposition in certain areas or to erosion subsequent to deposition (fig. 20). In places the sandstone or sandy shale which lies above the coal is apparently continuous with the sandstone below and the coal and accompanying strata are entirely absent. In other places the coal is found in more or less trough-like areas between sandstone ridges. It is thought that erosion subsequent to deposition is more largely responsible for the irregularity in distribution than is original irregularity of deposition.

There seems to be an area running southward through the Longwall District along the line of the Third Principal Meridian as a center in which a large number of holes shows No. 5 coal to be absent, and the mines also have found the coal unworkable. This area swings more to the east, north of the Illinois, but its exact extent is not known definitely. It seems probable that

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there is a considerable area where the bed is of unworkable character, if not absent, between La Salle and Spring Valley.

The best information concerning the character of this coal was obtained from the Matthiessen and Hegeler mine located in the NW. ¼ NW. ¼ sec. 14, La Salle Township. In this mine the coal varies in thickness from 24 to 66 inches and has an average thickness of about 48 inches (fig. 20). Irregularities and impurities are not continuous, but balls and lenticular bands of sulphur as much as 1 inch in thickness are not uncommon. The coal is of medium hardness, bright, blocky, and possesses a banded texture due to the inter-lamination of dull and glance coal.

Carbondale strata above Springfield (No. 5) coal.—Over the coal where it occurs normally is about 10 feet of dark-gray shale. This varies, however, to black, sheety shale or to limestone. Normally the overlying shale is brown and micaceous resembling the brown shale below the fire clay. In places the roof shale is overlain by sandstone of Carbondale age which may cut into or even apparently through it and cut out the coal and associated strata entirely.

MCLEANSBORO FORMATION

Name and definition.—The McLeansboro formation includes the Pennsylvanian rocks overlying the Herrin (Belleville or No. 6) coal of Illinois.

In this area where the Herrin coal is absent the McLeansboro formation is believed to extend from a horizon between the Springfield (No. 5) coal and the Streator (No. 7) coal to the top of the Pennsylvanian. The bottom of the sandstone lying upon the upper Carbondale strata described above is taken arbitrarily as the base of the formation, as it is thought in places at least to be an erosion surface. This sandstone is not always present, however, so that in many places it is impossible to indicate definitely the position of the boundary between the two formations. Outcrops of the strata between the two upper coals are least exposed of any in the Pennsylvanian section, and furthermore the section where exposed is shale rather than sandstone.

The formation may be divided lithologically into a lower arenaceous and an upper calcareous portion. The lower portion includes the Streator (No. 7) coal and terminates 40 to 70 feet above this coal. The upper portion includes the Lonsdale limestone near the base, the La Salle limestone toward the top and several other limestones thinner or of a less persistent character than these two, as well as numerous beds of nodular and calcareous shale.

Strata between the base of the McLeansboro and the Streator (No. 7) coal.—The lowermost stratum of the McLeansboro formation where it has been identified is the sandstone with irregular lower surface which overlies the Springfield (No. 5) coal in the Matthiessen and Hegeler mine at La Salle and in the mine at Cherry. The thickness of this sandstone is variable, but rarely over 25 feet. In a belt running southward between Cherry and La Salle

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toward Taft the sandstone has probably the greatest thickness and, as farther south in Putnam County, may extend across the horizon of the coal and lie upon the Vermilionville sandstone or the shale at the same horizon.

In the mine at La Salle the sandstone lies across the bedding of the older strata, in places cutting down into the coal, or forming the roof of the coal, or overlying the black shale or higher strata.

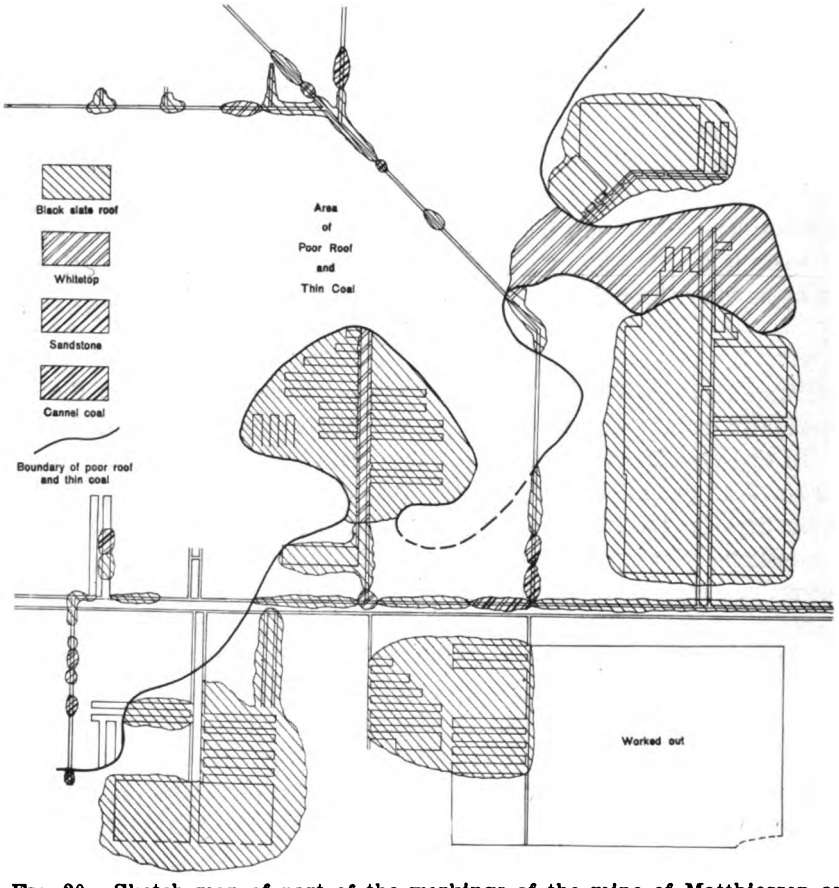

FIG. 20.—Sketch map of part of the workings of the mine of Matthiessen and Hegeler Zinc Company in SE. ¼ sec. 9, T. 33 N., R. 1 E., in the northwest part of the mine, showing distribution of various kinds of roof rock.

Between the sandstone described above and the underclay of Streator (No. 7) coal are variable thicknesses of shale and clay. Below are commonly the same brown, sandy, micaceous shales similar in character to other shales in this part of the Pennsylvanian section. Upon these brown shales rests the floor clay of the Streator coal. This clay has a thickness of 25 feet or less, 5

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to 7 feet being the average thickness. The upper 6 feet of the clay where it is thick is clean and regular; below that level it contains much sulphur.

Streator (No. 7) coal.—The name of the Streator (No. 7) coal is derived from the name of the town in the southern part of La Salle County where it was extensively worked for many years. It is commonly known in the La Salle region as the "First Vein" coal, and in the old system of nomenclature as coal No. 7.

The correlation of this coal in the northern part of the State with coals similarly numbered in the Peoria and Danville regions is more or less open to question. It is the only thick bed in the McLeansboro formation as now defined. The usual means of identification of this coal is not by physical characteristics nor by fossils, but by its position 25 to 70 feet below the Lons-

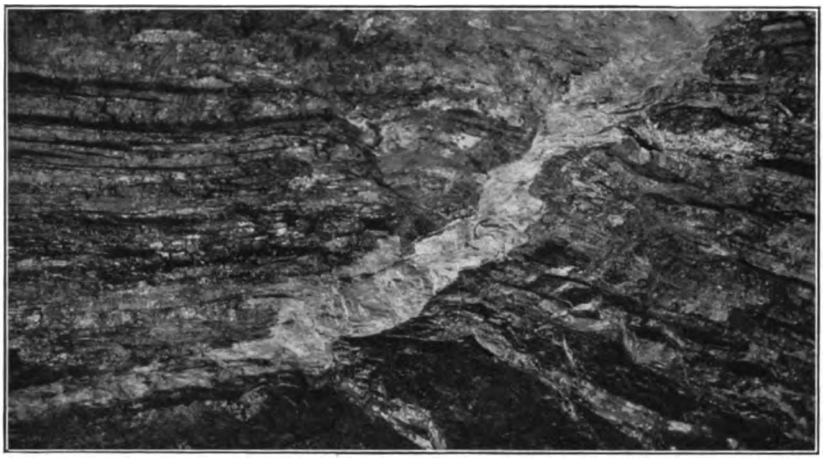

FIG. 21.—Streator (No. 7) coal cut by a "horseback" in the M. and H. mine, La Salle.

dale limestone. The interval is about 50 feet in this area. A limestone, probably the Lonsdale, outcrops in Rocky Run near Tiskilwa a short distance beyond the west boundary of the Hennepin quadrangle, and at Coal Hollow along Bureau Creek east of Princeton (fig. 22). The Streator (No. 7) coal in each case is found within 50 feet below.

The Streator (No. 7) coal, according to records from 41 test holes, has an average thickness of 39 inches. The average thickness in that part of the area lying in Bureau County is 35 inches; in Putnam County, 32 inches; and in La Salle County, 45 inches. Where measured in outcrop along Little Vermilion River it is 36 inches thick and in the Matthiessen and Hegeler mine at La Salle, 46 inches. This coal, like the bed below, is interrupted by vertical clay seams or "horsebacks" (fig. 21).

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The coal bed has not been seen at La Salle by members of the Survey except at one place in the Matthiessen and Hegeler clay mine. The picture shown in figure 21 is a view taken in the mine showing Streator (No. 7) coal at a place crossed by a "horseback." The coal seen to the right in the picture is apparently about normal. It is 46 inches thick and has no very distinct partings so far as could be determined.

Strata between the Streator (No. 7) coal and the Lonsdale limestone.— Above the coal is found a gray, carbonaceous shale about 6 feet thick, followed by 5 feet of drab-colored shale above. This upper stratum contains locally numerous ironstone concretions or "niggerheads" some as large as a baseball. In places a draw slate is present above the coal.

The exposures of the coal and associated strata in the quadrangles are unsatisfactory, so that dependence is placed upon an outcrop showing the coal and roof clay along Rocky Run near Tiskilwa about a mile west of the boundary of Hennepin quadrangle. Here the roof is a light-gray shale or "soapstone" extending above the coal for 6 feet 10 inches and becoming darker above. This darker shale contains locally streaks of calcareous ironstone 1 to 2 inches thick. In places the dark shale becomes sheety in structure, and contains fewer concretions. The dark shale has a thickness of 4 feet and is overlain by gray shale containing small concretions to a height of at least 30 feet.

Above the strata associated with the Streator (No. 7) coal are 40 to 70 feet of arenaceous sediments consisting of shales and sandstones. These strata show great irregularity in thickness and lithologic character. Along the anticline the section is about one-half as thick as elsewhere. These arenaceous strata form the top of the lower division of the McLeansboro formation. Above them lie 25 feet or less of calcareous shales commonly of a variegated color, which terminate at the Lonsdale limestone.

The following section from a shaft at Coal Hollow on the Hennepin quadrangle shows the character of the strata between a limestone thought to be the Lonsdale, and the Streator (No. 7) coal in the western part of the area.

Record of the Walton Shaft at Coal Hollow in the NE. ¼ SW. ¼ sec. 17, Selby Township

	Thickness		Depth	
	Feet	*Inches*	*Feet*	*Inches*
McLeansboro formation:				
Limestone (Lonsdale?)	6	6	6	6
Clay, blue, full of shells	1	6	8	..
Clay, blue	4	6	12	6
Clay, reddish brown	3	6	16	..
Clay, light gray	3	..	19	..

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Record of the Walton shaft at Coal Hollow—Concluded

	Thickness		Depth	
	Feet	*Inches*	*Feet*	*Inches*
McLeansboro formation—Concluded				
Sandstone, soft	7	10	26	10
Sandstone, hard, laminated	3	6	30	4
Sandstone, soft	3	6	33	10
Sandstone, coarse, dark gray	6	10	40	8
Soapstone, light gray	10	10	51	6
Clay, variegated; red, brown, and light blue	3	6	56	..
Shale, brown	3	6	58	6
Shale, grayish brown with shells	1	..	59	6
Shale, gray	17	..	76	6
Shale, black, fissile; fossils	6	..	82	6
Coal, Streator (No. 7)	2	2	84	8

Lonsdale limestone.—The name Lonsdale limestone is adopted from Worthen who used it in describing the limestone at the Lonsdale quarries near Peoria. It has subsequently been used by Udden.[1]

FIG. 22.—Lonsdale limestone at Coal Hollow. The ledge is about 4 feet in thickness.

Limestone like the typical Lonsdale occurs on the Hennepin quadrangle, only at Coal Hollow (fig. 22), but large masses of it are found outcropping in the till above Streator (No. 7) coal in Rocky Run at Tiskilwa about a mile west of the boundary of the quadrangles. A ledge of limestone having about the same relationship to Streator (No. 7) coal and lithologically similar though not so thick is found along the Vermilion rivers where they flow across the folded strata. This stratum probably appears in a number of drilling records as the first limestone above Streator (No. 7) coal.

[1] Udden, J. A., Geology of the Peoria quadrangle, Illinois: U. S. Geol. Survey Bull. 506, p. 39, 1912.

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The Lonsdale limestone resembles lithologically the La Salle limestone which is better known in this district. In the Peoria district, at Tiskilwa, and at Coal Hollow the rock has a concretionary or brecciated structure at the outcrop. The fragments of which the rocks are composed are dense, fine-grained, dark gray, fossiliferous, pure limestone, which breaks with a conchoidal fracture. The matrix may be fine-grained limestone like the fragments, but it is commonly argillaceous, especially where the rock is newly exposed. The stratum is commonly about 6 to 8 feet thick.

A small collection of fossils made from the exposure at Coal Hollow yielded the following forms as determined by Prof. T. E. Savage:

Fossils from the Lonsdale limestone at Coal Hollow

Rhombopora lepidodendroides Meek
Derbya crassa Meek and Hayden
Productus semireticulatus Martin
Marginifera splendens N and P
Pugnax uta Marcou
Squamularia perplexa McChesney
Spiriferina kentuckyensis Shumard
Hustedia mormoni Marcou
Composita subtilita Hall
Griffithides scitula Meek and Worthen

Strata between the Lonsdale limestone and the La Salle limestone.—For about 90 feet above the Lonsdale limestone the strata are irregular, calcareous, nodular shales and lenticular limestone beds. The thickest and best developed of these limestone lenses is that found about 115 feet above the Streator (No. 7) coal. Its typical outcrop is at the foot of the hill south of the town of Spring Valley near the depot of the Chicago, Rock Island and Pacific Railroad. The section shows 8 feet of nodular, fossiliferous limestone containing an argillaceous bed 4 to 6 inches thick about 1 foot from the bottom. Elsewhere this horizon is represented by nodular shale.

Because of the lenticular character of the strata lying between the horizon of the limestone outcropping at Spring Valley and the La Salle limestone a generalized section for the entire area is of little value. This part of the Pennsylvanian section is limited practically to the La Salle quadrangle, and knowledge of it is obtained from drill records and from numerous outcrops along the tributaries of the Illinois and along the Vermilion rivers.

The most complete and satisfactory section of this part of the McLeansboro formation is exposed along the lower part of Cedar Creek in secs. 28 and 29, T. 33 N., R. 1 E. The section is not complete at any one place but is compiled from measurements made at a number of exposures.

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A compilation of several measured sections of part of the McLeansboro formation along Cedar Creek in secs. 28 and 29, Peru Township

	Thickness		Depth	
	Feet	*Inches*	*Feet*	*Inches*
McLeansboro formation:				
24. Limestone, Productus bearing (base of La Salle limestone)	..	..	..	..
23. Shale (covered)	11	..	11	..
22. Limestone	..	10	11	10
21. Shale, black, sheety	2	3	14	1
20. Limestone lens, ½ to 4 inches	..	1	14	2
19. Shale, dark gray	4	4	18	6
18. Coal, 3¾ to 5 inches	..	5	18	11
17. Shale, black	..	2	19	1
16. Shale, dark gray	6	1	25	2
15. Shale, greenish to dark gray	1	..	26	2
14. Limestone, nodular	..	6	26	8
13. Clay, yellowish green, structureless	4	5	31	1
12. Shale, nodular, greenish gray	5	..	36	1
11. Shale, reddish	..	6	36	7
10. Shale, dark gray	2	..	38	7
9. Shale, greenish gray; with chunks of nodular limestone	2	..	40	7
8. Limestone, bluish green to gray, very argillaceous; fossils 2½ to 4 feet	3	..	43	7
7. Shale, gray to green; fossils	..	6	44	1
6. Shale, green to black; fossils	1	..	45	1
5. Shale, green with a thin streak of coal near the top	3	9	48	10
4. Shale, carbonaceous	..	6	49	4
3. Shale, dark to light gray	4	9	54	1
2. Shale, concretionary, red to gray, 8¾ to 10¼ feet	10	3	64	4
1. Limestone	2	..	66	4

La Salle limestone.—Of the strata comprising the McLeansboro formation the most conspicuous and the most important economically in the quadrangles is the La Salle limestone which outcrops along the bluffs of the Little

FIG. 23.—La Salle limestone in the west quarry of the Chicago Portland Cement Company, near La Salle. Photo by Rhodes.

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Vermilion, Big Vermilion, and Illinois rivers in the vicinity of La Salle. The base of the limestone member is arbitrarily taken as the top of a black, fissile shale about 1 foot thick, commonly associated with a seam of coal about 1 inch thick. This black shale forms the floor of the quarry of the La Salle (formerly German-American) Cement Company east of La Salle and appears in the clay pits below the limestone at the quarries of the two cement plants at Oglesby. The limestone terminates below a red, concretionary shale.

FIG. 24.—Strata at the horizon of the La Salle limestone in a gulley in Peru, showing the more siliceous phase.

The typical La Salle limestone is found only near the west flank of the anticline in a strip not much over a mile wide. As found at the cement quarries it is a succession about 30 feet thick of limestone varying from white, crinoidal and oolitic strata to brecciated, nodular, dense, thin-bedded layers. (See fig. 23). These latter beds are associated with different amounts of argillaceous material either between the beds or forming the matrix in which

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the limestone nodules are embedded. In all places where the limestone is typical it is highly calcareous, but may contain variable amounts of argillaceous material in certain beds. Such silica as is present is that found in finely divided state in the shale or, possibly, in silicates. The rock is essentially non-siliceous.

West from the Vermilion rivers the La Salle member becomes lithologically different because of the amount of argillaceous material in certain beds so that they become essentially shale, and an increase in the siliceous content in other beds so that they are eventually calcareous sandstones or very siliceous limestones (fig. 24). Not all the beds, however, are affected by these changes, some being very pure wherever exposed. This applies especially to the coarser white crinoidal beds.

The stratigraphic succession of the La Salle limestone member where it is typical has been compiled from observations at various exposures, at no one of which the section is complete. The sequence is about as follows:

A general section of the typical La Salle limestone

Formation and bed	Thickness	Depth
	Feet	*Feet*
McLeansboro formation:		
La Salle limestone:		
7. Limestone, very pure, semi-crystalline, gray; weathering to brownish or reddish color, 5 to 9 feet	6	6
6. Shale, gray; often entirely absent or incorporated in the underlying bed	2	8
5. Limestone, compact and heavy bedded where fresh but develops thin beds where weathered. A two-foot bed at the base is relatively constant over the entire area as a pure semi- crystalline gray limestone	12	20
4. Limestone or shale; south of the Illinois commonly argillaceous, thin bedded; north of the Illinois more argillaceous to nearly a shale 6 to 8 feet	7	27
3. Limestone, hard, gray, crinoidal. Over large areas about 1 foot thick, but near Vermilion rivers as thick as 6 feet	2	29
Base of the La Salle limestone:		
2. Shale, blue; locally absent	½	29½
1. Shale, black, sheety. 1 foot to 2¼ feet	2	31½
Gray shale below with a thin bed of coal, about 5 feet.		

Sections of the siliceous phase of the La Salle limestone are available at many places along the ravines tributary to the Illinois west of La Salle on both sides of the river. The following are samples:

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Section of the siliceous phase of the La Salle limestone member in the NW. ¼ SW. ¼ sec. 33, Hall Township, near mine No. 3, Spring Valley Coal Co.

	Thickness		Depth	
	Feet	*Inches*	*Feet*	*Inches*
9. Limestone, siliceous, argillaceous	12	..	12	..
8. Shale, light gray above, dark below	6	..	18	..
7. Limestone, gray, crinoidal	1	3	19	3
6. Shale, black, fissile	2	..	21	3
5. Shale, gray	4	..	25	3
4. Coal	..	6	25	9
3. Limestone, gray, concretionary	4	..	29	9
2. Limestone, hard, crinoidal	1	..	30	9
1. Shale, nodular, greenish	1	..	31	9

No. 7 above is the base of the La Salle limestone member. No. 9 is the *Productus*-bearing limestone.

The following fossils have been collected from the La Salle limestone member. The identifications were made by Prof. T. E. Savage:

Fossils collected from the La Salle limestone

Fossils	Typical La Salle limestone	Arenaceous La Salle limestone
Lophophylum profundum Milne-Edwards and Haime	X	..
Orbiculoidea subtrigonalis McChesney	..	X
Rhipidomella pecosi Marcou	..	..
Meekella striaticostata Cox	X	..
Chonetes granulifer Owen	..	X
Chonetes verneuilianus N and P	X	X
Productus cora D'Orbigny	X	X
Productus costatus Sowerby	X	X
Productus lasallensis Worthen	X	..
Productus nebraskensis Owen	..	X
Productus semireticulatus Martin	X	X
Marginifera splendens N and P	X	..
Pustula punctata Martin	..	X
Cryptocantha compacta W and St. J	X	..
Dielasma bovidens Morton	X	..
Spirifer cameratus Morton	X	X
Ambocoelia planiconvexa Shumard	X	..
Squamularia perplexa McChesney	X	X
Spiriferina kentuckyensis Shumard	X	X
Composita subtilita Hall	X	X
Sedgewickia topekensis Shumard	X	..
Aviculopecten hertzeri (?) Meek	X	..
Aviculopecten interlineatus M and W	X	..
Porcellia peoriensis or gillanus	X	..
Pharkidonotus percarinatus Conrad	X	..
Murchisonia sp	X	..
Euconospira turbiniformis M and W	X	..
Pleurotomaria spironema M and W	X	..
Platyceras parvum Swallow	X	..
Temnocheilus latus M and W	X	..
Metacoceras sangamonensis M and W	X	..

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McLeansboro strata above the La Salle limestone.—Rocks similar to those below the La Salle limestone continue above that member of the McLeansboro formation. The area underlain by these strata is small, being confined to Peru and La Salle townships, to sec. 6, Vermilion Township, and to sec. 1, Eden Township. The strata are exposed along Illinois River, the Vermilion rivers, and Bailey Creek in the valley bluffs. A measured section of this part of the McLeansboro formation is given below.

Sections of that part of the McLeansboro formation above the La Salle limestone member. Measured along the road south of La Salle in secs. 22 and 27, La Salle Township

Surface elevation 600 feet above sea level at the top

	Thickness		Depth	
	Feet	*Inches*	*Feet*	*Inches*
Pleistocene: Drift, till, red to yellow	10	..	..	..
McLeansboro formation:				
11. Shale, bluish gray	3	..	3	..
10. Shale, grayish yellow	5	..	8	..
9. Shale, nodular, calcareous	5	..	13	..
8. Shale, dark, to light gray	10	..	23	..
7. Limestone, shaly	2	..	25	..
6. Shale	2	..	27	..
5. Limestone, dark, impure	1	3	28	3
4. Shale	..	4	28	7
3. Coal	..	8	29	3
2. Shale, gray to blue	10	..	39	3
1. Shale, red	20	..	59	3
Top of the La Salle (*Productus*-bearing) limestone.				

Certain strata represented in the foregoing section are of especial interest. The shales numbered 10 and 11 and a still higher one are used in the manufacture of pressed brick at Peru. The nodular calcareous shale, No. 9 in the preceding section is locally a limestone. In the ravine in the NW. ¼ sec. 27, La Salle Township (T. 33 N., R. 1 E.), there is at this horizon at the head of the gully a semi- crystalline, very fossiliferous, white limestone. The fauna is very different from that of the strata below, such as the La Salle limestone, being conspicuous for the great numbers of gastropods and lamellibranchs and the numerous sharks' teeth. Also embedded in the limestone are small pebbles of greenish, igneous rocks and quartz.

Tertiary (?) System

Neither Mesozoic nor Tertiary rocks are found in place in the quadrangles, but the basal part of the glacial drift in several places contains many well-rounded pebbles of quartz. Here and there are found small deposits of quartz and chert gravel containing some pebbles of igneous rock, all colored a dark

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red by iron oxide. Such a deposit is found under the more recent gravels at Spring Valley in the SW. ¼ sec. 35, Hall Township. At this place there are 6 to 10 feet of greatly oxidized quartz pebbles lying above the "Coal Measures" strata and underlying a bed of silt or loess. A fragment of a leg bone of a species of elephant was found in this gravel. The deposit here is thicker than it has been found elsewhere, but traces of its presence have been observed in the gullies between Peru and Spring Valley, especially those in sec. 19, Peru Township, and in several of the ravines on the south side of the Illinois west of Cedar Creek. A deposit resembling shingle was noted in the ravine south of Spring Valley in the E. ½ sec. 27, Granville Township, lying at the base of the drift and composed of fragments of the siliceous La Salle limestone.

Whereas these deposits at the base of the drift are possibly of Pleistocene age, they indicate the previous wide distribution of quartz gravels over this area. Fragments of similar conglomerate are found widely distributed over the southern part of the Mississippi Valley and as far north as the quartzite ridges at Devils Lake, Wisconsin. They are commonly regarded as being the product of an extended erosion period during the Lafayette epoch of the late Tertiary.

Quaternary System

Pleistocene series

The Pleistocene deposits are believed to represent seven of the stages of Pleistocene time in North America. It is probable that the lowest drift exposed within the area and encountered in numerous test holes drilled for coal belongs to a pre-Illinoian stage. This drift has overlying it in places a bed of silt and organic material resembling a forest soil thought to be possibly of Yarmouth age. Overlying the oldest drift or the Yarmouth soil is a till believed to be Illinoian, and this in turn is overlain by the Sangamon soil. This latter deposit is not uncommonly associated with a body of loess or silt possibly of Sangamon, Iowan, or Peorian age. The uppermost till of the area is thought to be the Early Wisconsin till, and except for areas where it has been eroded this drift underlies almost the entire area. Certain of the terrace deposits bordering the larger valleys may be of late Wisconsin age. Covering almost the entire surface of the area is a thin layer of pebbleless silt somewhat similar to loess which seems to have been deposited soon after the Wisconsin ice melted away.

Although all these deposits are exposed at the surface it is thought best because of the difficulty in many places of separating the two older drifts to show on the surficial geology sheet only the distribution of the two upper till sheets.

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PRE-ILLINOIAN DRIFT AND YARMOUTH (?) SOIL

The exposures of pre-Illinoian till are found almost entirely in the numerous ravines which cut into the bluff of the Illinois Valley on the west side of the La Salle and the east side of the Hennepin quadrangles. The greater mass of this earliest drift is found below an elevation of 500 feet and in the pre-glacial valleys.

Rather large bodies of drift, possibly pre-Illinoian, occupy the lower part of the pre-glacial Rock-Illinois Valley which runs through the central part of the Hennepin quadrangle. The tributary valleys of this early stream were also in part filled with the pre-Illinoian drift. So far as has been discovered the Illinois Valley east of the bend at Hennepin does not contain any of the oldest till.

The oldest till is best exposed where the present drainage has cut deeply into the filling of the pre-glacial valleys. A noteworthy example is in the ravine in the W. ½ sec. 28, Granville Township (T. 33 N., R. 1. W.). The till here exposed at an altitude of about 530 feet, is dark gray, fine grained, and tenaceous, and contains organic matter such as partly decayed sticks. In one place this till is overlain by a bed of silt, the lower part of which is bluish in color and the upper part black with organic matter. This silt is overlain by Illinoian drift which is about 25 to 30 feet thick and which is in turn overlain by the Wisconsin till at an altitude of 600 to 620 feet.

In the Hennepin quadrangle the older drift seems to be largely sand and gravel and to lie at a lower level than it does on the La Salle quadrangle. Exposures of till as definitely separated as those in the La Salle quadrangle have not been observed in outcrop, though certain exposures of dark-gray, adhesive boulder clay at elevations below 500 feet have been suspected of being older than Illinoian. Knowledge of the oldest drift is obtained almost entirely from drilling. Its determination is based upon the existence at the top of a muck or soil bed which is thought to separate the Illinoian from the older drift. This soil bed is found in many of the drill holes at an elevation of from 500 to 540 feet above sea level.

A tabulation of the character of the material composing the drift on the Hennepin quadrangle below an elevation of about 500 feet, which is about the elevation of the soil bed marking the top of the pre-Illinoian drift on this quadrangle, shows a great preponderance of sand and gravel over other kinds of drift. Although it is impossible to separate gravel of two drift sheets from the data recorded in the logs, yet where two gravel beds each of considerable thickness are separated by a forest soil bed or a silt at the same elevation over a considerable area, it is believed that a considerable difference in age between the gravel beds is indicated.

The correlation of the oldest drift on this area with deposits in other regions cannot be made with certainty because of the meagerness of the infor-

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mation concerning it. If this dark-gray, indurated till found below or at the base of the Illinoian drift in this area is of either Kansan or Nebraskan age, the more widespread distribution of the Kansan drift makes its presence in this region more probable than that of the older drift.

PRE-ILLINOIAN LOESS AND SILT

Associated with the Yarmouth or pre-Illinoian soil bed, and where it is so associated commonly overlying the soil bed, is a variable thickness of fine silt or loess of a yellow to blue color. This silt is found from place to place at elevations varying from 480 to 520 feet above sea level along the streams issuing from the north and south bluffs of the Illinois west of the anticline and east of the mouth of Bureau Creek.

The silt is a very fine, even-grained material, compact where moist and dust-like where dry. When dry it is more commonly yellow than blue. It is in places stratified and elsewhere unstratified. Not uncommonly it contains numerous shells of land and fresh water gastropods. This deposit, though evidently of greater age, resembles in many particulars the silt and loess found between the Illinoian and Wisconsin drifts about 100 feet higher in the section.

There are numerous localities where this pre-Illinoian silt is exposed. The most continuous and best exposures are found along the valley of Spring Creek and in the tributary valleys that enter from the west in sec. 26, Hall Township. Along this valley unlaminated and structureless brown, yellow, or blue silt or loess lies at the bottom of the deposit. This material contains shells in considerable numbers. It is from 10 to 20 feet thick at least, the base of the silt being nowhere exposed. Overlying the unlaminated silt are about 10 feet of laminated silt which contains an increasing number of small, water-worn pebbles toward the top, and grades without apparent break into a pebbly, yellowish till, apparently the Illinoian drift.

In the various drilling records that have been given, sections of this silt bed are shown at the base of the Illinoian till. Such a deposit is found in many of the deep drift wells and coal borings of the area especially in the Hennepin quadrangle. In places it probably acts as a reservoir for natural gas originating in the drift.

ILLINOIAN DRIFT

The greatest mass of drift in the area is probably of Illinoian age. It is found at the surface in most places where Wisconsin drift has been eroded. In general it is more widely distributed in the pre-glacial valleys that were cut below 600 feet above sea level. Rock surfaces that are higher than 600 feet do not commonly have any cover older than the Wisconsin drift, except possibly in the vicinity of Granville.

The Illinoian drift is thickest along the west side of the area particularly

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along Bureau Creek west and south of Princeton where 150 feet are probably present. The average thickness is about 100 feet, which distance represents about the average interval between the forest soil beds at the base and at the top of the Illinoian drift. The altitudes at which the lower soil bed is found vary from 500 to 540 feet above sea level, possibly to 560 feet, and the upper soil bed is found between 600 and 640 feet.

On the La Salle quadrangle the Illinoian drift is thin, varying from as little as 5 feet along Bailey Creek to possibly as much as 70 feet. There are no known outcrops of the Illinoian till north of the Illinois and east of the Little Vermilion within this area.

The Illinoian drift in this region includes sand and gravel as well as till. The till is rather variable in character. On the Hennepin quadrangle it is of a brownish to reddish color where slightly weathered, as in a stream cut that

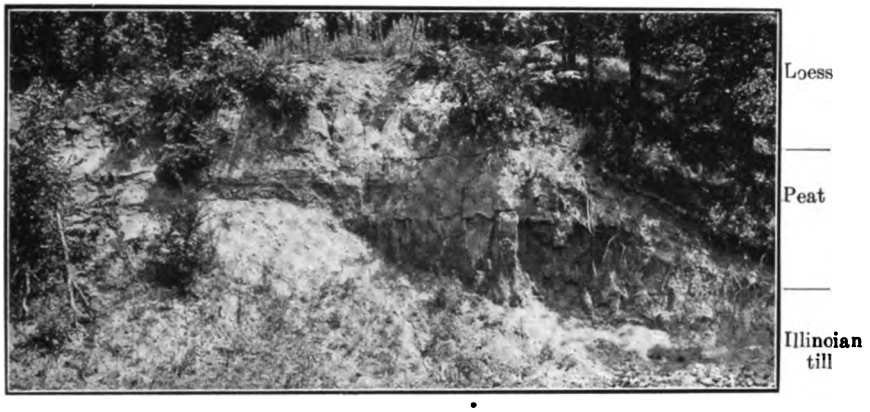

FIG. 25.—Buried peat of the Sangamon interglacial epoch, lying above Illinoian till and below loess along East Bureau Creek near the center of N. ½ sec. 8, Selby Township.

has dried at the surface, but where fresh it is gray to yellowish to buff colored. It is generally blocky and too hard to be easily penetrated by a trowel. Not uncommonly it is cut by cracks which run vertically through the till and along which the material is oxidized for the width of an inch or two.

Toward the east the Illinoian till has a yellowish rather than a reddish color. Along Cedar Creek, the till varies in color from gray to buff and yellow. The same is true of the till along the valleys of the Little Vermilion and Spring Creek. In the vicinity of Spring Valley there is a considerable thickness of a dark, dirty, grayish till, hard when fresh, which is thought to be Illinoian in age, but which may be older.

Not uncommonly the upper 10 feet or so of the Illinoian till shows evidence of having been leached and oxidized before the deposition of the over-

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lying Wisconsin drift. The leached zone of the older till is, in general, thicker than that of the Wisconsin till.

Gravel deposits of Illinoian age are not separable lithologically from the later gravels.

Exposures of the Illinoian till are very numerous. Along the north and east bluff of Bureau Creek the Illinoian till makes up practically the whole section from where the valley opens into Illinois Valley as far north as the center of Dover Township (T. 17 N., R. 9 E.). Good exposures have also been observed along East Bureau Creek, Little Vermilion River, Vermilion River, and Cedar Creek. Two measured sections are given below.

Section of the drift north of the Illinois and Mississippi Canal in the NW. ¼ sec. 9, Arispie Township

Measurements approximate. Observations by U. S. Grant. Surface elevation 565 to 575 feet±

	Thickness	Depth
	Feet	*Feet*
Loess, yellow	5	5
Sand and gravel	3	8
Till, light red to yellow	15	23
Sand and gravel	3	26
Till, light reddish to gray	7	33
Sand, fine; not well exposed	25	58

Section of Illinoian drift in an old gravel pit in the SW. ¼ SE. ¼ sec. 8, Leepertown Township, near Bureau

Observations by U. S. Grant

	Thickness		Depth	
	Feet	*Inches*	*Feet*	*Inches*
Loess-like material, yellow, pebbleless	4	..	4	..
Illinoian till, weathered passing into	1	..	5	..
Till, red, freely effervescing, with small irregular patches of gravel scattered throughout	9	..	14	..
Gravel and sand, not well exposed	25	..	39	..
A few rods southwest of the latter and lower down				
Gravel (the same as the last) cemented into rough, craggy forms	25	..	25	..
Till (pre-Illinoian) dark gray, with the upper 1 to 2 feet changed to yellow or yellow-brown material by oxidation. Not leached	10	..	35	..

Not uncommonly within the main body of the Illinoian till well below the top, there are found thin lenses of yellowish silt or possibly loess resembling the silt found between the Illinoian and Wisconsin tills. These silts are not associated with soil beds in any known instance, at least, and the till above and below them is of the same character.

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SANGAMON INTER-GLACIAL DEPOSITS

The interglacial stage following the Illinoian stage is called the Sangamon stage because of the widespread development of a soil and peat bed above the Illinoian drift in Sangamon County, Illinois. The Sangamon soil is well exposed in the Hennepin and the La Salle quadrangles (see fig. 25), and it has been noted in many wells and coal borings. It is probably persistent over many square miles especially within the Hennepin quadrangle along lines of interglacial drainage. Where the present valleys have cut down to the level of the floors of the older drainage lines the soil is often exposed.

The deposits in this area thought to have been formed during the Sangamon interglacial stage are silt and beds of peat or soil. Furthermore, a leaching of the upper few feet of the Illinoian till is evident in many places. The

FIG. 26.—"Forest bed" below loess near the same location as the buried peat of figure 25.

beds of silt are similar to those found beneath the Illinoian drift; that is, structureless to laminated, blue and buff-colored silt or loess of very fine texture, carrying numerous shells of land and fresh water gastropods. The beds of peat are made up of greater or less amounts of vegetable matter and silt such as is found in the silt beds. In places the bed is largely organic matter, being composed of partly decayed or even well-preserved, closely matted pieces of wood, such as the twigs and branches of trees.

At no place where a peat bed was observed was there decisive indication of its having been formed in place. Roots extending into the underlying drift were not seen and logs and twigs lie horizontally. The deposits seem to be drift wood of local origin.

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The oxidized zone of the upper part of the Illinoian drift may extend as much as 7 feet below the top of the till. Where the peat or forest bed is present the oxidized zone lies below. At other places there may be yellow or blue silt above the oxidized zone or even the unoxidized pinkish Wisconsin till.

Localities along the contact of the two tills where the Sangamon soil may be observed are indicated on the map showing the preglacial surface (Plate V), by a small cross and figures indicating the approximate elevation of the soil bed. These figures will be observed to range from about 600 feet to about 635 feet and to be confined for the most part to the lower parts

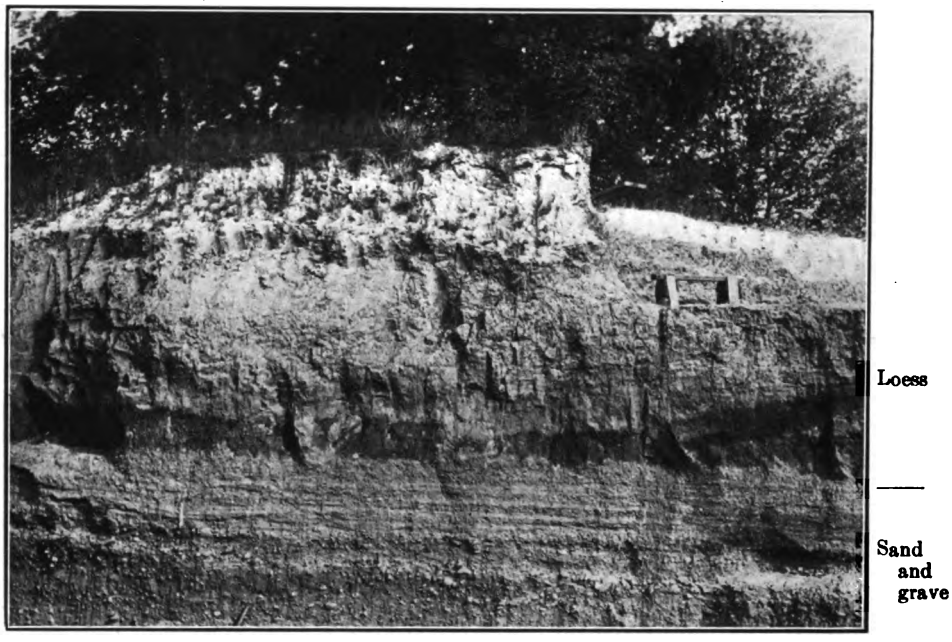

FIG. 27.—Loess above gravel of probable Illinoian age, east of Princeton.

of the basins of East Bureau and Negro creeks, with a few localities along the south bluff of the Illinois and in the tributary ravines.

LOESS AND SILT BETWEEN THE ILLINOIAN AND WISCONSIN TILL SHEETS

As elsewhere in Illinois the Sangamon soil bed is associated with a deposit of silt and loess (fig. 26). The material composing this deposit is a friable, uniformly fine-grained, dust-like material, which may or may not be laminated. It usually contains more or less lime carbonate, and is not uncommonly fossiliferous. The deposit resembles the silt lying below the Illinoian till, though it is possibly less commonly of a bluish color where exposed.

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The thickness of the silt or loess between the Wisconsin and Illinoian tills is variable but where it is most characteristically developed in association with the underlying forest bed it commonly has a thickness of about 10 feet. In those parts of the area where the Wisconsin drift is not present and the Illinoian is the underlying till, this loess may appear at the surface. Loess and silt 6 to 9 feet thick is found at the top of the bluffs from place to place north of Bureau Creek in the west half of Arispie Township. Fig. 27 shows this loess above gravel east of Princeton along Bureau Creek. Thick surface loess is found in the hilly area east of Hennepin in secs. 6 and 7, Granville Township, and in secs. 1, 11, and 12, Hennepin Township. No outcrops of till have been observed along the gullies and roads in this region above an elevation of 640 feet, though doubtless in the cores of the hills it rises to a higher elevation.

EARLY WISCONSIN DRIFT

THICKNESS AND DISTRIBUTION

Drift of Early Wisconsin age probably originally covered the entire surface of the quadrangles, but has been removed over considerable areas bordering the larger streams, especially along Illinois River on the east side of the La Salle quadrangle. Many of the streams have cut through the Wisconsin drift into one of the older drifts or into the rock and exposed sections of the till or gravel along the valley walls.

The drift of Wisconsin age is remarkably thin over much of the area especially toward Illinois Valley and in the southwestern part of Hennepin quadrangle. The thinness of the deposit is in part due to erosion but principally to meagerness of deposition. Between Bureau Creek and East Bureau Creek south of Princeton the drift of the Wisconsin epoch is confined to a slightly elevated ridge with morainic expression running north from sec. 5, Arispie Township, toward Princeton.

On the south side of Bureau Creek Valley the Wisconsin drift seems to be present only toward the crest of the divide running through secs. 19, 20, 23, 24, 28, and 29, Arispie Township, which forms the watershed for Bureau Creek and streams to the south. The divide follows a line of irregular hills with morainic expression thought to have originally been continuous with moraine running northeast through Princeton. The disorganized character of the upland topography indicates that much of the Wisconsin till could not have been removed, and therefore that it was never of great thickness.

On La Salle quadrangle there is an area of about 2 square miles lying west of Pecumsaugan Creek in sec. 6, Utica Township, and extending southwest to the outcrop of the La Salle limestone in the NW. corner sec. 13, La Salle Township, where there is very little drift other than boulders 4 feet or less in diameter scattered here and there over the surface, but not in great pro-

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fusion. This apparently is an area from which all but the heaviest and coarsest parts of the latest drift have been washed. A similar area from which at least part of the upper till has probably been washed, borders the Illinois Valley from La Salle to Spring Valley through secs. 16, 17, and 18, Peru Township, and secs. 35 and 36, Hall Township, and also west of Spring Valley in secs. 33, 34, and 35 of the same township.

There is, so far as is known, no till present in the inner Illinois Valley, though gravel and sand, possibly in part of glacial origin, are found there in considerable quantities. There are numerous terraces bordering the streams which were formed after the invasion of this area by the ice and which are not primarily of glacial origin.

In the northeast part of the Hennepin quadrangle where the Wisconsin drift seems to be thickest, as much as 141 feet of what is probably this drift has been encountered in one of the drill holes. From this extreme thickness it decreases in amount southward toward the Illinois Valley as described in the preceding paragraphs. It seems therefore that although over much of the area this drift is thin, it nevertheless attains a thickness in places greater than that known to be reached by either of the other drift sheets.

TILL

The Wisconsin till where it is typically developed is of a drab color with a rather conspicuous tinge of pink. In the exposures along Vermilion River, especially the pink color of the upper till in contrast to the yellowish color of the lower is unmistakable. Toward the west side of the Hennepin quadrangle the older till has a brownish or reddish tinge, is therefore easily confused with the pink of the upper till, and the separation of the tills on the basis of color is impracticable. There is a slight difference in color, however, which can be seen when the two tills occur in the same exposure, as along East Bureau Creek in sec. 8, Selby Township. Over a large part of the La Salle quadrangle the lower till is yellowish or gray and readily separable from the upper where the two occur in the same section.

Although the difference in color is useful as a means of separating the two tills it is not a criterion of wide application. It is serviceable in restricted areas and especially where colors can be readily compared without trusting to memory. The relative age of the tills in each region of numerous exposures may be first determined by the usual criteria after which the color is useful in tracing the drifts from place to place.

The Wisconsin till is notably unconsolidated as compared with the more or less jointed Illinoian. It is rather friable, easily penetrated with pick or trowel, and is always calcareous nearly to the top. Not uncommonly it is very stony, almost a gravel, and then it is in general of a yellow color. The pebbles and larger fragments in the till are dominantly limestone or dolomite with a

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relatively small percentage of flints and quartz. The larger boulders are predominantly of dark diabase which weathers to a grayish exterior. Boulders of red quartz porphyry are not uncommonly found in the till or apparently weathered out of it.

The character of the Wisconsin till in various parts of the area is sufficiently well shown in the numerous sections already given in the description of the earlier drifts to make unnecessary the introduction of additional drilling records or measured sections.

SAND AND GRAVEL

Between the sand and gravel of Early Wisconsin age and that of Late Wisconsin or even of Illinoian age the writer has found no lithologic difference.

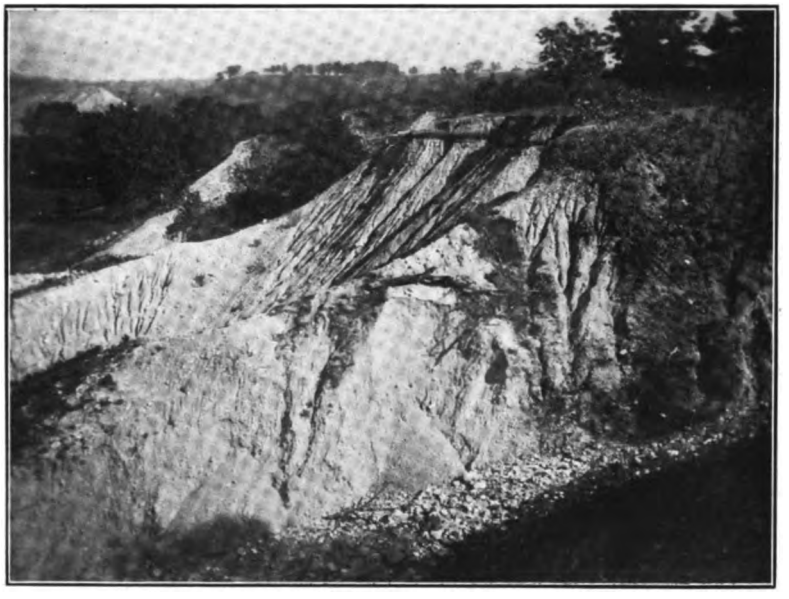

FIG. 28.—Gravel pits east of Spring Valley.

Certain gravel deposits are known to be of Illinoian age because they lie within bodies of Illinoian till, but they are not markedly different from other gravels underlying or overlying Wisconsin till. In general the gravel deposits of Wisconsin age in the area may be regarded in part as Early Wisconsin in age and in part as younger than Early Wisconsin. The earlier gravel lies without the valleys or forms the valley walls in places, and the younger gravel is found within the valleys principally as valley trains or terrace deposits.

Of the Early Wisconsin gravel there may be two kinds, the gravel deposited on the surface formed during the Sangamon (Illinoian-Wisconsin)

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interglacial stage as the Wisconsin ice sheet advanced, and hence underlying the Wisconsin till, and that formed while the ice was moving back and forth over the region and hence deposited within or above the till sheet.

Several large bodies of gravel underlying Wisconsin till and practically unweathered are thought to be of Wisconsin age. The age is unquestionable where they overlie the soil and silt beds of the Sangamon stage where they in turn rest upon Illinoian drift. It is open to question where they overlie unweathered Illinoian till, the Pennsylvanian or older rocks, or silt and buried peat resting upon pre-Pleistocene strata.

Of the gravel of probable Early Wisconsin age there are numerous outcrops along the bluff of Illinois River from one side of the area to the other. Heavy deposits of gravel are found near Utica, La Salle, Spring Valley, between Depue and Bureau, and south of Bureau on the west bluff of the Illinois, all of which are thought to have originated with the ice advance of the Early Wisconsin stage. This does not include the Hennepin gravels which lie within the Illinois Valley and are of a later origin.

As the gravel at Spring Valley (fig. 28), has been studied in some detail and as it is typical of the group a description of the characteristics displayed at that locality will suffice for all the exposures.

The gravel in the pits at Spring Valley has a thickness of about 60 feet. The section is about as follows:

Section of the gravel in the pits near Spring Valley on the east side of the valley of Spring Creek. SW. ¼ sec. 25, Hall Township

	Thickness		Depth	
	Feet	*Inches*	*Feet*	*Inches*
7. Clayey surface soil	2	..	2	..
6. Sand, coarse, like torpedo sand	2	..	4	..
5. Sand, fine, well sorted	1	3	5	3
4. Loess, yellow	1	6	6	3
3. Sand and gravel, coarse, dipping 25° W.; upper surface and contact with loess is level	40	..	46	..
2. Loess, yellow, in part laminated, about	5	..	51	..
1. Gravel, many quartz and flint pebbles, much oxidized	10	..	61	..
Pennsylvanian series.				

The gravel of bed No. 3 in the section given above is poorly sorted but at the same time is well stratified in layers dipping west at a high angle. The boulders contained in the gravel vary greatly in size up to 3 or 4 feet in diameter. The limestones are very rarely decayed but the boulders of igneous rock are commonly so soft that they can be easily penetrated with a trowel or pick. There are also many fresh boulders of igneous rock. Numerous boulders of till are also scattered throughout the deposit. These may be as

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large as 1½ feet in diameter but are commonly smaller. They are generally coated with small pebbles and broken surfaces show the characteristics common to the tills of the region. Till balls of at least three different colors have been observed, reddish, gray, and yellowish gray, mainly the tills characteristic of the older drifts. The till is commonly indurated and characterized by the presence of small quartz and flint pebbles.

MORAINES

The various halts of the ice sheet that deposited the Early Wisconsin drift in this area are marked by lobate recessional moraines. One of these moraines crosses the La Salle quadrangle east of La Salle (fig. 29), and another composite moraine is found on Hennepin quadrangle. They have been previously described and named in Chapter III on the topography of the quadrangles. The moraine in the Hennepin quadrangle is the Arlington moraine and comprises an outer or west branch, the Dover moraine, and an inner or east branch, the Coal Hollow moraine. The moraine in the La Salle quadrangle is known as the Grand Ridge or Farm Ridge moraine.

FIG. 29.—Farm Ridge moraine north of Illinois Valley.

The moraines are composed almost entirely of till, but lenses of gravel are found which increase in thickness toward the west. In some cases, as on the north side of the Illinois along Tomahawk Creek, the gravel beds slope sufficiently to give an artesian head to the water contained in them.

POST EARLY WISCONSIN DEPOSITS

GRAVEL

The later Wisconsin gravel of this area is in the main that found within the valleys and is of two sorts, that found in the terraces and that forming part of the valley filling. The former is thought to be of glacial origin in part at least and to have been formed when the ice edge was not far to the east of this region. The gravel forming part of the valley filling is possibly of more recent origin, having been deposited after the Illinois Valley ceased to be the outlet of glacial Lake Chicago.

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The terrace gravel composes the terraces bordering the valleys, the surface elevation of which varies from about 480 to 575 feet above sea level. The most notable example is the Hennepin gravel underlying the Hennepin terrace. Other gravel deposits of the same age as the Hennepin gravel are found along streams tributary to the Illinois but apparently not elsewhere along the Illinois Valley within this area.

The Hennepin gravel is most extensively exposed along Allforks Creek in secs. 25 and 36, Hennepin Township, (T. 33 N., R. 2 W.), where it is being excavated at large pits. The gravel composing the Hennepin terrace extends down to at least 480 feet above sea level in one place (SW. ¼ NW. ¼ sec. 35, Hennepin Township), in the central part of the terrace and at Hennepin to an elevation of about 400 feet. In general as compared with the earlier gravel, this deposit is finer, better sorted and apparently lacks the till balls commonly found in earlier gravels. Other terrace gravel probably of the same age is found in isolated patches along the larger streams.

The Hennepin gravel was deposited after the ice withdrew from this region and before the valley was the outlet of glacial lake Chicago, and probably represents a valley train extending west past the Marseilles moraine. Terraces of the same age are found along the Illinois south of this area as an examination of the topographic sheets of the Lacon, Dunlap, Metamora, and Peoria quadrangles will show. East of the bend in the Illinois at Bureau no deposits of this age have been identified in this area within the valley. Their absence is thought to be due to their removal, if they were ever deposited, by the waters of the outlet river from glacial lake Chicago, removal being more complete in the narrow rock-bound valley above the bend than in the wider valley below.

Gravel underlying terraces of a later date than the Hennepin terrace is relatively unimportant. It is common along all streams but especially along Bureau and East Bureau creeks. Such terraces are difficult, probably impossible, to correlate with each other or with the different events of the physiographic history of the region following the deposition of the Hennepin terraces. Even the Hennepin terraces in the upper part of the streams where relief is less are indistinguishable from later ones.

LOESS

The surface of the area except for small areas on the upland and the most recent flood plains of the streams is covered with loess or silt similar to loess varying in thickness from a few inches up to 15 feet or more. In those parts of the region where there is no Wisconsin till in the section the upper part of the loess is probably of Wisconsin or later age, whereas the lower part is possibly of late Sangamon age, and represents the outcrop of the loess found

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here and there between the Illinoian and Wisconsin drifts. This thick loess has previously been described as pre-Wisconsin loess.

The latest loess, which lies at the surface, is distributed alike over moraines and till plains, except that in certain poorly drained areas which until very recently have been swamps the loess, if any is present, is obscured by the presence of large quantities of humus rendering the soil black. Over such parts of the area as have been more or less modified by water as especially the various terraces and high-level benches, the loess seems to be of secondary origin being mixed to a slight degree with small stones and pebbles. Such secondary loess is found on the high benches along the bluff of Illinois River and along similar benches on the smaller streams, such as Vermilion River and Bureau Creek.

RECENT SERIES

DUNE SAND

Deposits of dune sand are found only on the Hennepin terrace. Dunes are distributed along the crest of the terrace and the sand of which they are built is apparently derived from the slope to the west and possibly also from the river flood plain. Some of the dunes are somewhat crescentic in shape with the horns pointing with the wind, others are of no definite form. The west side of the hills is almost invariably the steeper. The height of these dunes on the upper terrace is apparently as much as 15 feet, though the height is often difficult to determine because the slope of the west side of the dune is a continuation of the slope of the hill to the west. These are actively shifting dunes. Another area of shifting sand forms the top of the bench or terrace running north from Hennepin at an elevation between 500 and 520 feet above sea level. A third area of dune sand lies at the base of the drift hills at the east side of the Hennepin terrace especially in sec. 11, Hennepin Township.

ALLUVIUM

Deposits of alluvium are present along most of the streams, but most notably along Illinois River. Of the smaller streams those in the Hennepin quadrangle have the widest flood plains. Except for Negro Creek these valleys have not reached the rock, but are cut entirely in drift. In the La Salle quadrangle the flood plains are narrow and insignificant along the streams where the elevation is less than 560 feet above sea level, but are commonly well developed above that elevation. The preservation of the alluvium in the upper part of the valleys is due, along some streams at least, to the establishment of a temporary base level at the elevation of a resistant rock ledge through which the stream cuts with relative slowness. This relationship is well illustrated by the distribution of alluvium along Cedar Creek and

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Bailey Creek, the flood plains essentially terminating where the outcrop of the La Salle limestone crosses the valleys. In other cases it is possible that the wider upper flood plain along some streams may represent practically the level reached while the Illinois was depositing the Hennepin terraces.

Along Illinois River the amount of alluvium in the valley varies greatly. As indicated in Chapter III on topography the rock floor of the valley is believed to represent the channel of the river which was the outlet of glacial lake Chicago, at least as far west as the bend at Bureau. West of the anticline the old channel has become filled with alluvium to a thickness of about 100 feet in one place at least and generally along the middle of the valley to a thickness of about 60 to 90 feet. East of the anticline for about 1½ miles, in places indicated by the swampy areas on the topographic map, are deposits of alluvium and peat of unknown thickness. Much of the east half of sec. 18, Utica Township, and thence east to the boundary of the quadrangle is underlain by rock with only a soil or with no covering. This surface is very irregular due to the presence of elongated hills of dolomite separated by swampy depressions probably containing more or less alluvium. South of the bend at Bureau the thickness of alluvium is difficult to estimate as the gravel in the channel is essentially like the gravel in the drift below and the position of contact impossible to determine in the one available drill record.

In the area between the anticline and the bend at Bureau there has been extensive drilling, so that in the vicinity of La Salle and Peru at least the character and depth of valley filling is well known, and is composed of surface alluvium, blue or yellow silt, and gravel.

The blue silt which is found 20 to 25 feet below the surface is generally present on the east side of the highway in secs. 15 and 22, and extends eastward at least beyond the La Salle city wells in the SW. ¼ SW. ¼ sec. 14, La Salle Township. It is due doubtless to the presence of this blue clay, which resembles the blue silts associated with the till sheets of the region, that the water in the lower gravels is not contaminated by the surface and river water.

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CHAPTER V--STRUCTURE

Definition

The term *structure* as used in geology commonly refers to the attitude or "lay" of the rock layers, that is, whether they are flat lying, inclined, folded, or broken by faults. Structure of this kind can be represented by photographs and sketches, by diagrammatic cross-sections and block drawings, but most accurately by means of structure contours.

Structure of the Quadrangles

The structure of the pre-Pennsylvanian rocks underlying the area is shown in Plate III, by contours based upon the elevation of the surface of the St. Peter sandstone.

Structure Contour Map

A structure contour map is similar to a surface contour map but differs from it in showing the elevation of the top or bottom of a selected stratum rather than the elevation of the surface of the ground. The detail of the structure contour map is much less than that of the surface map, because the elevations of all points on the surface can be readily determined, whereas the elevation of a buried stratum is known only at outcrops and where it has been reached by the drill or mine shafts. Such data is obviously neither systematically arranged or evenly spaced over large areas.

Uses of Structure Contours

The primary use of the structure map is to show the structural features. The key rock slopes or dips from the contour lines of higher elevation to those of lower, and in this way the map shows the "lay" of the strata. The map can also be used to determine the approximate depth of the coal bed used as a key rock and of other beds of known interval above or below the key stratum. It can thus be used for locating coal, clay, limestone, and water-bearing rocks.

One of the special services of the coal structure map in Illinois has been to determine the possible areas of oil and gas accumulation. It has been found as a rule that structural features affecting the "Coal Measures" affect also the underlying rock to a considerable depth in the same way, though possibly to a greater or less degree. A relationship of areas of accumulation to anticlinal folds and domes is known to exist, and the fact that, at least in some

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places, domes in the coal strata indicate conditions favorable for oil and gas has given added value to structure contour maps of the coal beds.

Accuracy of Structure Contours

The accuracy of the structure contours is determined first, by the number and distribution of the observations; second, by the reliability of geologic data, which involves the accuracy of statement by those from whom the information is sought, the accuracy of the location of the drill holes, and correctness of correlation of strata at outcrops and in drill holes; and third, by the method of determining the elevation of the bed to be contoured.

In the accompanying structure maps of the Hennepin and La Salle quadrangles (see Plate II in pocket, and fig. 28), the reference strata used are the La Salle (Third Vein or No. 2) coal, which is the most widespread and extensively worked coal bed in the area, and the St. Peter sandstone. Both have numerous natural exposures along and east of the La Salle anticline. Elsewhere the sandstone is widespread beneath the older rocks and the coal has nearly as general a distribution. Several artesian wells reach the sandstone and the coal has been penetrated by mine shafts and borings. These represent about the only source of information concerning the structure west of the anticline and away from the Illinois Valley. They are numerous except in the east half of the Hennepin quadrangle especially south of Bureau Creek. In this part of the area the structure of the rocks is not known. Near the Illinois and in a few tributary valleys outcrops substantiate the interpretation of structure as determined by other methods.

The drilling records are based upon diamond-drill borings under competent supervision and are judged to be accurate. Generally it was possible to locate accurately the exact position of the drill hole, and the consistency of the structure as delineated precludes the probability of great error from inaccurate location. The correlation of the recorded strata at the different drill holes is open to doubt only in a limited area in the vicinity of Bureau where the La Salle coal is thinner than common and liable to confusion with one or two probably lower thin coals of restricted distribution.

The structure of the St. Peter sandstone, as shown in Plate III, is generalized since it is less accurately known than the structure of the coal. Except for a single boring for oil, the artesian wells afford the only information concerning the altitude of the sandstone, and most of these are located along or south of the Illinois. The elevation and location of these wells were determined with a possible error of not more than 5 feet, and the depths were probably reported correctly since the top of the sandstone is an easily recognized horizon.

Three methods are used by the Survey to determine elevations: (1) by

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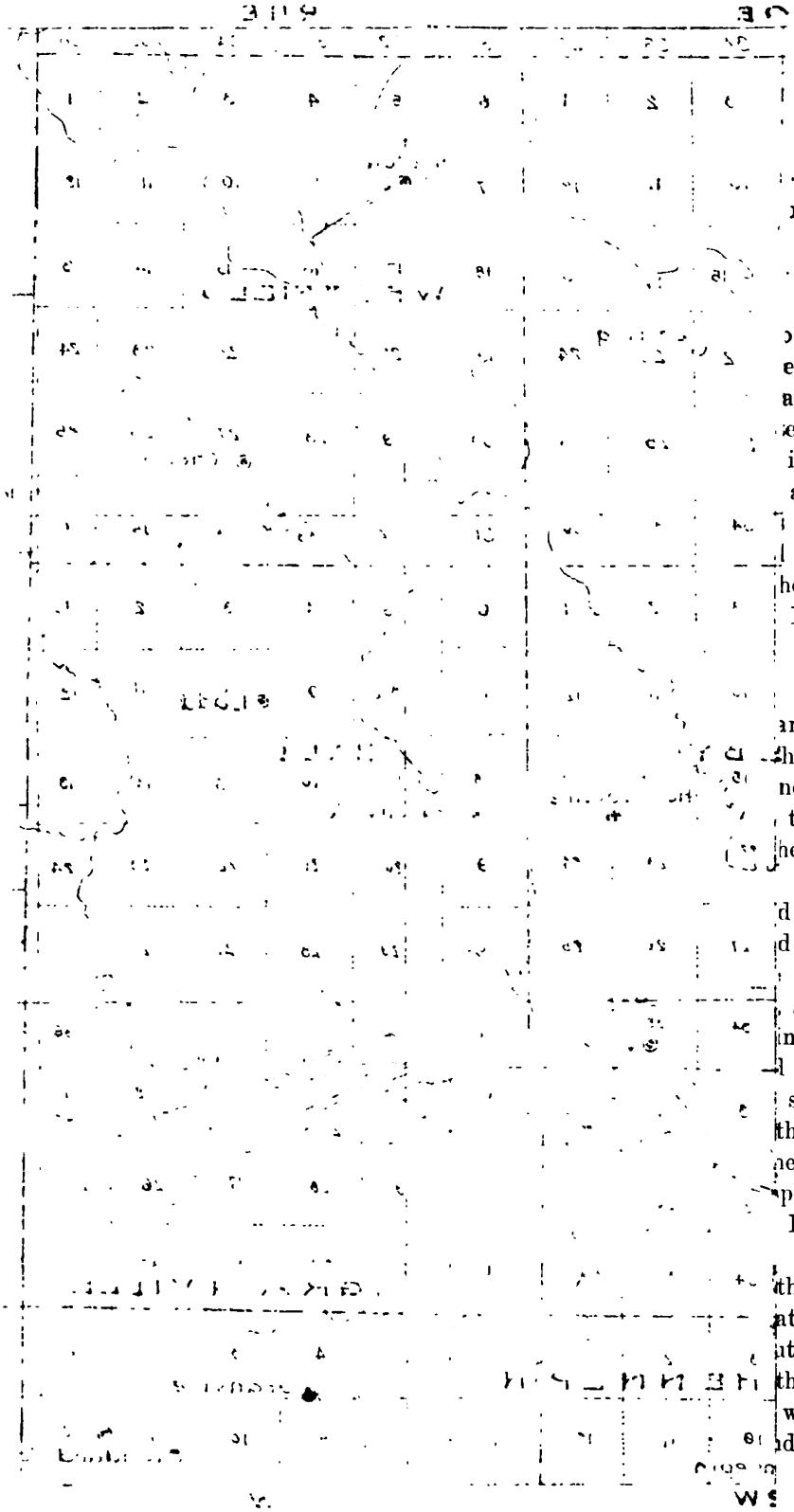

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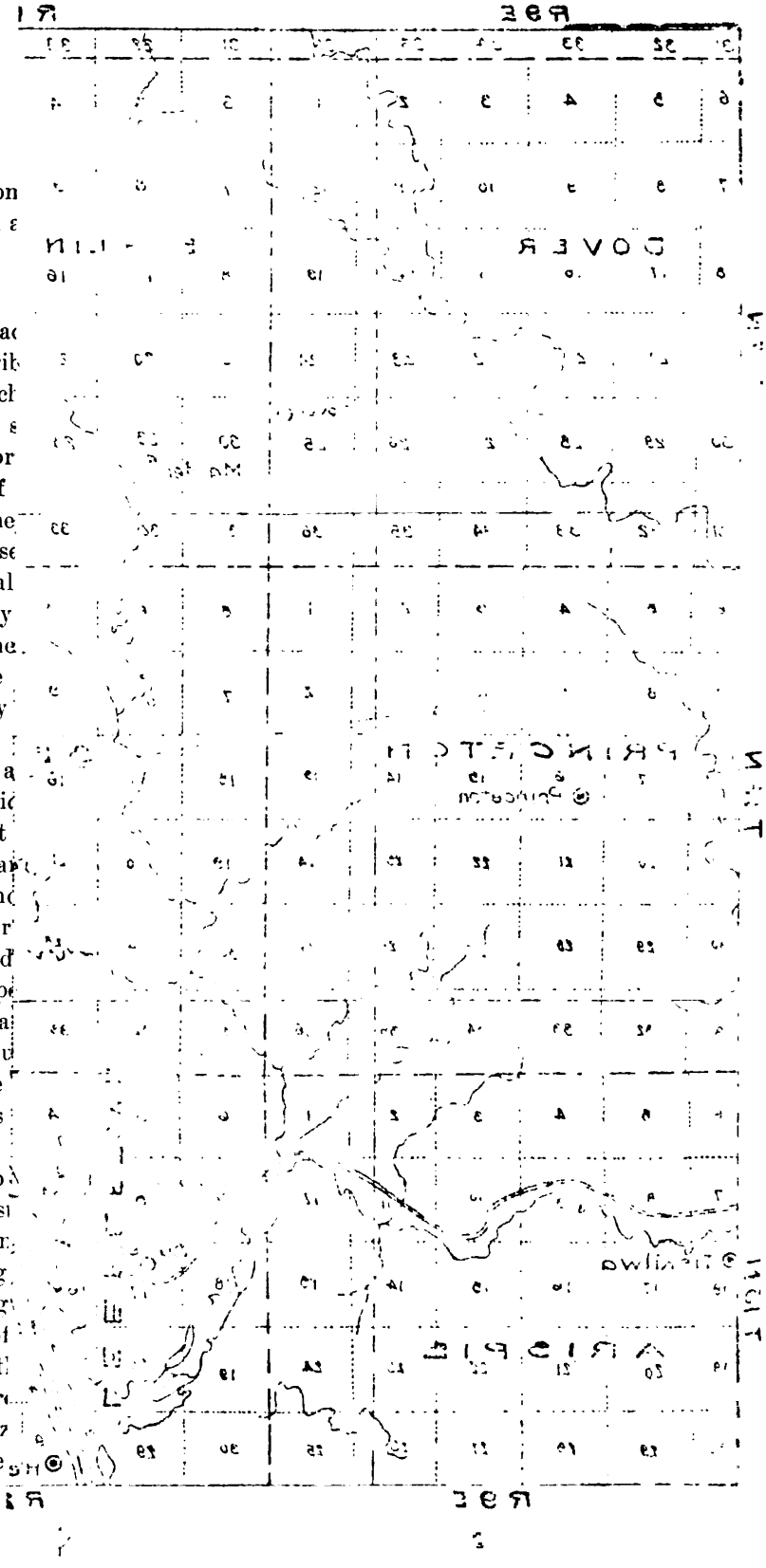

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accurate instruments, with a negligible error; (2) by hand-level line from adjacent bench marks, with a possible error in this region, where bench marks are numerous, of rarely more than 5 and usually less than 3 feet; and (3) by estimation from the contour map direct in the field with a possible error about the same as the 20-foot contour interval.

The surface of the coal, especially, and probably also that of the sandstone is somewhat more irregular than the contours indicate. There are local variations in the elevation of the coal as great as 10 or 15 feet that cannot be shown because of the largeness of the contour interval. The intervals, however, are sufficiently large to minimize the effect of slight errors in elevation to which the map is liable, as noted in preceding paragraphs, and at the same time it is sufficiently adequate to show the main structural features of the area. It is believed that the structure lines for the surface of the coal are correct within a contour interval, that is 25 feet, and for the surface of the sandstone within one-half a contour interval or 50 feet. (See Plates II and III).

Structure of the Quadrangles

In the Hennepin and La Salle quadrangles the layers of hard rock are not horizontal, for an important structural feature, known as the La Salle anticline, is pronounced. This is more correctly called a monocline, since the fold is step-like, with the depression on the west side. West of the fold all the strata of the bed rock slope toward it. To the east, however, the strata dip slightly east from the crest of the fold to the State line.

The altitude of the top of the sandstone has been determined at about a dozen wells scattered over the area at numerous outcrops along and east of the anticline. The overlying Ordovician and Silurian rocks are apparently approximately parallel to the surface of the St. Peter sandstone, so that the contours, drawn at intervals of 100 feet vertically, show the main structural features of all the formations between the Pennsylvanian series and the "Lower Magnesian" formations. Concerning the structure of the older strata little is known. Data based upon the records of three wells west of the anticline indicate a general parallelism of the "Lower Magnesian" with the St. Peter. East of the fold where it outcrops the Shakopee dolomite displays minor undulations which are not known to continue above into the St. Peter sandstone.

In the Hennepin and La Salle quadrangles the altitude of the La Salle coal west of the outcrop along the anticline has been ascertained at about 100 places. Most of the data are derived from mines and coal tests, but some have been obtained from well borings. Several determinations near the anticline were calculated from the outcrops of black slate, the distance of which above the coal is known. Along the anticline in the valleys of Illinois and Little and

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Big Vermilion rivers, and west of the anticline along Illinois Valley there are many exposures of the coal to which measurement has been made direct. The contour lines on the structure map (Pl. II in pocket), are based upon these figures and they show the elevation of the coal in feet above sea level, being drawn at intervals of 25 feet vertically.[1]

The La Salle anticline crosses the area in a direction varying from N. 40° W. at Arlington to N. 27° W. where it is crossed by Illinois Valley, 1½

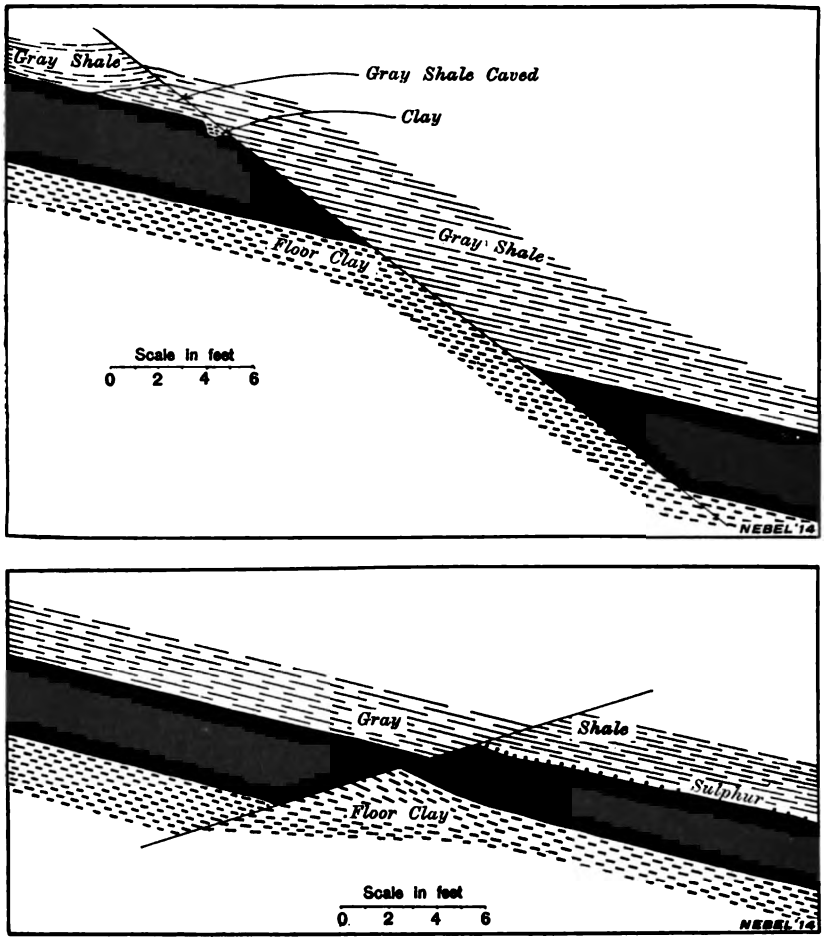

FIG. 30.—Normal faults in Black Hollow mine.

miles east of La Salle, to nearly north and southeast of Bailey Falls and west of Lowell. The steeply dipping west limb of the anticline has a width of

[1] In Plate II the closed contour in secs. 20 and 29, Berlin Township, should be designated 275 feet, that in secs. 25, 26, 27, 34, and 35 of the same township also 275, and that 1½ miles north of La Salle, 100.

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one-half to three-quarters of a mile along Illinois River and at Deer Park, but the strata continue to rise for about one-half mile east of the steep inclination. To the northwest and to the south the dip of the west limb apparently becomes less abrupt than it is along the Illinois, but exact values are wanting. Near Deer Park the La Salle coal is known to dip in places as much as 52 degrees, but the usual exposed dip of the Pennsylvanian series rarely exceeds 15 degrees. At such places the underlying Ordovician rocks dip 30 to 35 degrees, and it is not known whether this dip increases toward the trough of the fold.

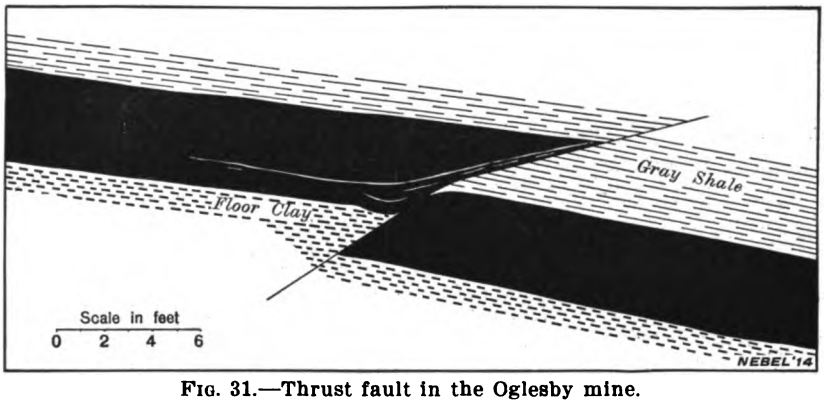

FIG. 31.—Thrust fault in the Oglesby mine.

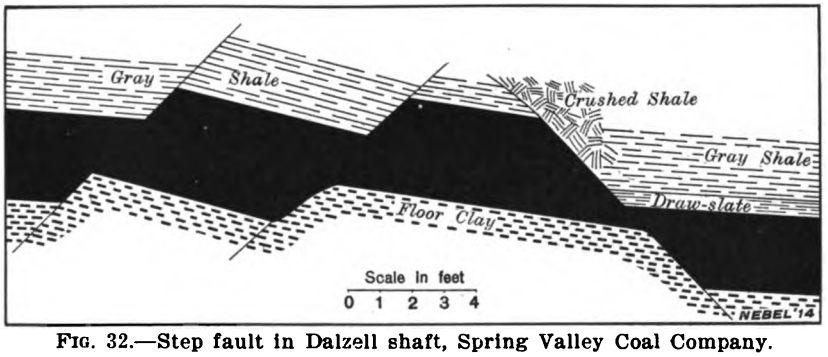

FIG. 32.—Step fault in Dalzell shaft, Spring Valley Coal Company.

Because of this structure the La Salle coal, which east of the anticline has an altitude of 610 feet or slightly more, west of the anticline in the trough parallel to the fold has an altitude of only about 100 feet above sea level.

All the Pennsylvanian strata west of the fold dip eastward or southeastward at a low rate averaging about 12½ feet to the mile from the probable outcrop northeast of Princeton to the bottom of the trough near La Salle. The actual dip is greater to the west than near the anticline. Considerable differences in the altitude of the coal have been noted within short distances

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of Bureau, the elevations being constantly greater to the east as is shown by map. There is a gradual rise of the floor of the trough parallel to the anticline both to the northwest and to the south which accompanies the decrease in the strength or height of the anticline in the same directions. The rise to the south from Oglesby is at the rate of about 2 feet per mile and to the northwest from La Salle probably as much as 10 to 12 feet to the mile. East of the crest of the anticline the coal dips very gently to the east, possibly about 5 feet to the mile.

Minor irregularities in the structure of the "Coal Measures" strata, especially of the coal beds not brought out by the map are not uncommon. The coal in any mine does not lie perfectly horizontal or dip uniformly in any direction, but small, broad basins rarely over 20 feet in depth are found here and there throughout the area (see Plate IV). These are not, however, of sufficient importance to affect mining materially.

In Black Hollow and Oglesby mines small faults have been observed affecting the coal and adjacent strata. In no case does the throw amount to more than the thickness of the coal bed. Figs. 30, 31, and 32 illustrate observed faults in these two mines. Nearly vertical slickensided planes traverse the roof shale. In addition to these faults, slipping has also occurred along bedding planes, with the result that commonly the upper layer of coal fingers off into the shale and is bent back in the direction of movement. In poorly consolidated beds, such as the roof shale of La Salle (No. 2) coal, irregular fracturing has been produced, so that upon undermining the coal the roof shale falls away in irregular masses, the sides of which are slickensided surfaces. Small faults have also been observed in the mine at Dalzell. In general faults are unimportant in the area, and those observed are confined to the strata associated with La Salle (No. 2) coal. None has been observed in the pre-Pennsylvanian strata.

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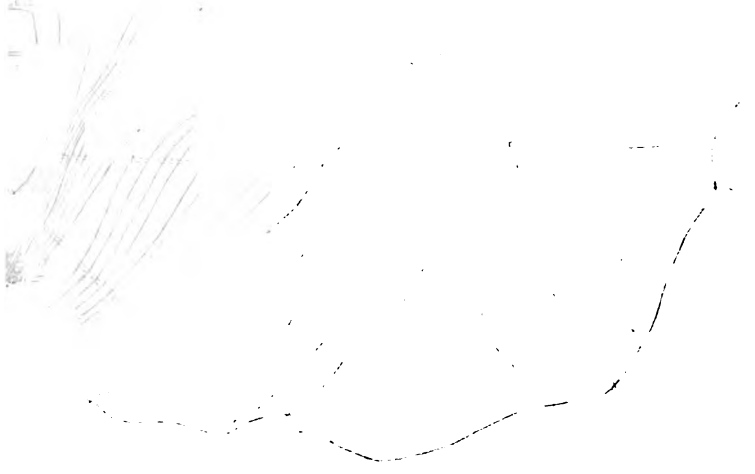

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CHAPTER VI—GEOLOGIC HISTORY

Imperfection of the Record

The record of the geologic history of this region is read in part in the outcropping rocks and in part in the rocks known only from drilling. There are long gaps in the record, some of which can be filled by facts inferred from the results of studies in other areas in the province, but of other gaps the story cannot be supplied with satisfaction even by inference. The data are most complete for several periods of the Paleozoic era and for the latter part of the Quaternary era, but this represents but a small fraction of geologic time. Of the long history before the Upper Cambrian epoch we have no knowledge except as inferred from the history of adjacent regions. The main outlines of this history were presented in the introductory chapter on the history of the province. Erosion has erased the record of events during Mesozoic and Tertiary eras so that this part of the story is exceedingly fragmentary in the Glaciated Plains province.

Paleozoic Era

CAMBRIAN PERIOD

At the opening of the Paleozoic era the surface of Illinois had probably been above the sea for a long time and had been eroded until it was nearly flat. Early in the era the region was gradually submerged and sandy deposits were laid down in the encroaching sea. The submergence probably took place in Middle Cambrian time and lasted at least until the close of Cambrian time.

This upper Cambrian formation is not exposed or known from drilling in this region but it has been reached by the drill at Ottawa, Illinois, and at other places farther east and probably underlies this entire area.

After the deposition of this great formation which reached a maximum thickness of 1,000 feet, there appears, from the record elsewhere, to have been a withdrawal of the sea from the Central Mississippi area, if not from the whole continent, accompanied by uplift and erosion.

Ordovician Period

LOWER AND MIDDLE ORDOVICIAN EPOCHS

In the early Ordovician time the sea again advanced over this region and a great series of strata, the Prairie du Chien group of formations, was

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deposited. During this period of deposition conditions must have fluctuated sufficiently to allow the deposition at times of massive dolomite and at other times of sandstones. Toward the end of the earlier epoch when the Shakopee dolomite was being deposited conditions of relatively shallow water prevailed as is indicated by the evidences of shallow water deposition found in the strata. Ripple marks, oolite, brecciated limestone, thought to be possibly largely the result of chemical precipitation point to shallow water origin. Probably sometime after the deposition of the Shakopee dolomite and before the deposition of the overlying St. Peter sandstone, slight deformation of the Shakopee seems to have taken place.

At the close of the period in which the Shakopee dolomite was deposited the interior sea was withdrawn and widespread erosion followed. Possibly gentle folding of the Shakopee formation took place at this time and produced the gentle undulations in the dolomite as exposed between La Salle and Utica. During this erosion interval the Shakopee member suffered considerable loss of material. The irregular upper surface of the dolomite exposed over the area is indicative of considerable relief due to erosion and to deep surface weathering. As a result of the latter process a mantle of regolith two or three feet thick and composed of residual clay interspersed with undissolved flint and siliceous nodules is found lying between the "Lower Magnesian" and the St. Peter formations.

At the end of this period of uplift and erosion the sea gradually advanced on the land and this area formed part of a broad shallow basin where wave and wind action was of such character as to form great deposits of pure white sand. Mr. E. O. Ulrich regards the St. Peter sandstone as a well-developed beach formed of wind-transported quartz grains from the north, and hence is in part a land deposit.

With the close of St. Peter time there was a period of non-deposition which is less important than the one at the base of the St. Peter and in many places is unrecognizable structurally. Following the emergence was a transgression of the sea in Platteville time. The area was covered by waters that probably were warm and free from much sediment, and the limestone composed of the remains of various marine animals was deposited immediately overlying the sandstone with relatively slight transition.

A relatively unimportant emergence separated Platteville from Galena time. The Galena is remarkably free from shale and sand impurities, indicating a constancy of level. This epoch closed with widespread emergence. At some period following the deposition of the Galena and before the deposition of the Pennsylvanian rocks further folding occurred along the axis of the La Salle anticline.

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UPPER ORDOVICIAN EPOCH

The next series of rocks, the Maquoketa limestones and shales, represents a period of fluctuating conditions and shallow water. At certain times great quantities of mud were brought into the sea from lands adjoining this district on the north. At other times the sea became clearer and possibly deeper and allowed the deposition of limestone in more or less lenticular beds.

SILURIAN PERIOD

The Maquoketa closes the marine Ordovician record in this region. The region remained emergent for a long time after the last Ordovician sediments were deposited.

The Silurian period like the Ordovician was characterized by constant oscillations of the strand line, and the system is made up of many formations representing various epochs in the history. As our knowledge of the Silurian in this region is based entirely upon drilling records and drill cuttings from a number of wells, it is impossible to determine what members of the system are present except by inference. The widespread distribution of the Niagaran dolomite in Illinois makes it probable that much of the heavy white dolomite found in the artesian wells was deposited in the great epi-continental sea which covered large parts of the interior in middle Silurian or Niagaran time. Whether the earlier or later incursions of the Silurian sea are represented in the section is not known.

DEVONIAN PERIOD

If, as may be possible, part of the limestone found in some of the deep wells underlying the Pottsville formation is of Devonian age, it was probably deposited following a lapse in sedimentation which was general in the province between Silurian and Devonian periods. The sea which advanced over parts of western Illinois in Middle Devonian time possibly reached this region, the incursion being recorded in some if not all the strata included in the upper part of the limestone and dolomite series between the Pottsville and the Maquoketa.

Late Devonian deposition may have taken place in this region and the rocks later eroded, since shale overlying probable Devonian limestone is reported by Udden[1] in a well as near Henry, in Marshall County, Illinois.

CARBONIFEROUS PERIOD

MISSISSIPPIAN EPOCH

Although Mississippian rocks are found in considerable thickness in the vicinity of Peoria there is no evidence that the seas of that period extended

[1] Udden, J. A., Some deep borings in Illinois: State Geol. Survey Bull. 24, p. 56, 1914.

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as far north as the Hennepin and La Salle quadrangles. Through all this long epoch, therefore, this region, so far as we know, was a land surface subjected to the processes of weathering and erosion.

PENNSYLVANIAN EPOCH

Pottsville erosion and deposition.—Preceding the deposition of any Pennsylvanian rocks in this region was extensive erosion of the older rocks. If rocks younger than the Galena extended across the anticline these were entirely removed along the crest and for some distance down the flanks of the fold. The erosion surface also truncated the Galena-Platteville formations and extended into, if not through, the St. Peter sandstone. The resulting surface did not have great relief but along the west side of the anticline the surface was possibly 50 to 100 feet lower than to the east of the fold. The dip of the older rocks along the west limb of the anticline was about one-half of what it is at present, and to the east they lay nearly flat; thus the fold had even greater resemblance to a monocline or step fold than it has at present.

The pre-Pennsylvanian erosion lasted possibly through the Mississippian epoch and certainly during the early part of the Pottsville stage. As coarse clastics are lacking in any Pottsville beds that have been observed it seems probable that the relief was not great and hence the stream erosion was here not rapid in early Pennsylvanian time. Denudation by solution was probably more important than erosion by streams. Considerable thicknesses of residual clay accumulated above the limestones from which it was formed, some of which was washed by the streams into the depressions such as that lying parallel to the anticline. North of the present position of the Illinois Valley, the pre-Pottsville surface extended across the Platteville limestone and upon the St. Peter sandstone. From this sandstone surface was derived the sand which lies interbedded with the clays or forms most of the Pottsville section as the case may be, the sandstone increasing in relative amount toward the north where the St. Peter underlies the "Coal Measures." It is believed that the Pottsville period terminated with the formation of an essentially level surface of clay or sand extending wide-spread over the area.

Carbondale deposition.—During the deposition of the Carbondale sediments the region was at times covered by the sea and received deposits of mud, both aluminous and calcareous, and of sand, and at other times the sea was essentially banished for longer or shorter periods, when the surface commonly stayed so low and so level that brackish or fresh water marshes covered large areas, in which were accumulated beds of vegetal matter that were afterward transformed into coal. A large part of the sand may have been deposited on land, but the limestone and some of the shale formed during that time contain well-preserved remains of marine animals, showing conclusively that the rocks in which they are found were deposited in the sea.

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There appear to have been also times of both local and general emergence and erosion, though the erosion was not nearly so extensive as that at the beginning of the preceding Pottsville epoch. Conditions generally were more quiet than in that epoch. Sand beds, though in some places coarse and thick, were not so extensive, and clay was the predominant material laid down. Peat made up a larger part of the deposits formed in this epoch than in any other.

McLeansboro deposition.—Between McLeansboro and Carbondale times there seems to have been a cessation of deposition in this area at a time when marsh conditions existed farther south and west toward the interior of the Illinois basin represented by the Herrin (Belleville or No. 6) coal. Erosion of the Carbondale formation seems to have locally exposed to surface conditions the Springfield (No. 5) coal and in places even to have entirely removed it.

With the subsequent advance of the sea coarse sand and siliceous mud filled the irregularities of the surface. Where the sand overlay the weathered Springfield (No. 5) coal it penetrated the joints and bedding places loosened by weathering. The resulting rock is the peculiar mixture of sand and coal observed in mines and known as "white top."

Eventually the sea was again filled and marsh conditions on a large scale prevailed for the third time in this region. In this period the peat forming Streator (No. 7) coal was accumulated. There followed further subsidence accompanied by the deposition of 50 to 60 feet of arenaceous deposits.

The remaining Pennsylvanian strata record a continuation of shallow-water deposition upon a gradually subsiding sea floor. The conditions were probably more continuously marine than they were earlier in the epoch as is indicated by the greater number of limestones carrying marine fossils.

POST-CARBONIFEROUS DEFORMATION

Carboniferous deposition was closed by widespread movements, which resulted in the uplift of the Appalachian Mountains on the east and the Ouachita and Ozark mountains to the west. These movements permanently banished the sea from the region. At this time or later there took place further movement along the line of the Ordovician fold. An additional 500 feet of throw was added to the displacement resulting in a total difference in altitude of 1,500 feet between strata on the two sides of the fold. Several small ridges and basins found in the "Coal Measures" probably originated at this time.

MESOZOIC ERA

Following the withdrawal of the sea and the deformation near the close of the Paleozoic era the processes of erosion and weathering became active on the new surface. In the time that followed during the Mesozoic era the level of the sea fluctuated greatly, but it is not known to have advanced over central

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or northern Illinois. Local warpings possibly took place accompanying the greater movements in the bordering mountain regions with a resulting acceleration of erosion from time to time, but the records of such cycles have been erased by subsequent erosion. In southernmost and in northernmost Illinois the tops of certain hills of resistant rock apparently constitute remnants of peneplains older than any recorded in the Hennepin and La Salle quadrangles; hence a cycle of uplift and erosion sems to have taken place before the oldest surface in the quadrangles was formed.

CENOZOIC ERA

TERTIARY PERIOD

DEVELOPMENT OF RELIEF

The processes that prevailed during Mesozoic time continued until the close of the Cenozoic. During the latter part of this era the land was essentially a plain, as the surface upon which the glacial deposits rest is very even except that here and there narrow valleys were cut. The present average elevation of this plain beneath the drift is about 600 feet above sea level in this region. When it was formed it was probably more nearly at sea level.

Near the close of the Tertiary period there was apparently a general uplift of the land, which accelerated erosion and caused the streams to deepen their valleys. Wells within the area show that several such valleys crossed these quadrangles, the rock floor below which, at one place at least, was about 250 feet below the surface of the plain into which the valley was cut. An elevation of only 350 feet above sea level of the rock floor is indicated by drilling near Bureau. From the data afforded by 500 to 600 wells and from coal borings in the area it is possible to reconstruct the general form of the bed-rock surface before glaciation. (See Plate V).

The Tertiary drainage lines differed considerably from those existing at present. A large and deep valley ran south across the west side of the Hennepin quadrangle. The center of the valley lay about at the position of Princeton, where it turned slightly southeast toward Bureau and then continued southward slightly east of the center of the present Illinois Valley. This valley is thought to have been occupied by a large stream coming possibly from the direction of Rock River. As a large river valley crossed the area it is apparent that the Tertiary plain into which it was cut would be less well preserved within these quadrangles than in other areas at a greater distance from this valley.

Lateral valleys of considerable size extending from the east half of the La Salle quadrangle were tributary to the large valley. The two most important of these lay one to the north and one to the south of the present valley of the Illinois east of the bend. Characteristics of the valley south of the

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glacial surface and the altitude of buried soils in the Hennepin and La Salle quad

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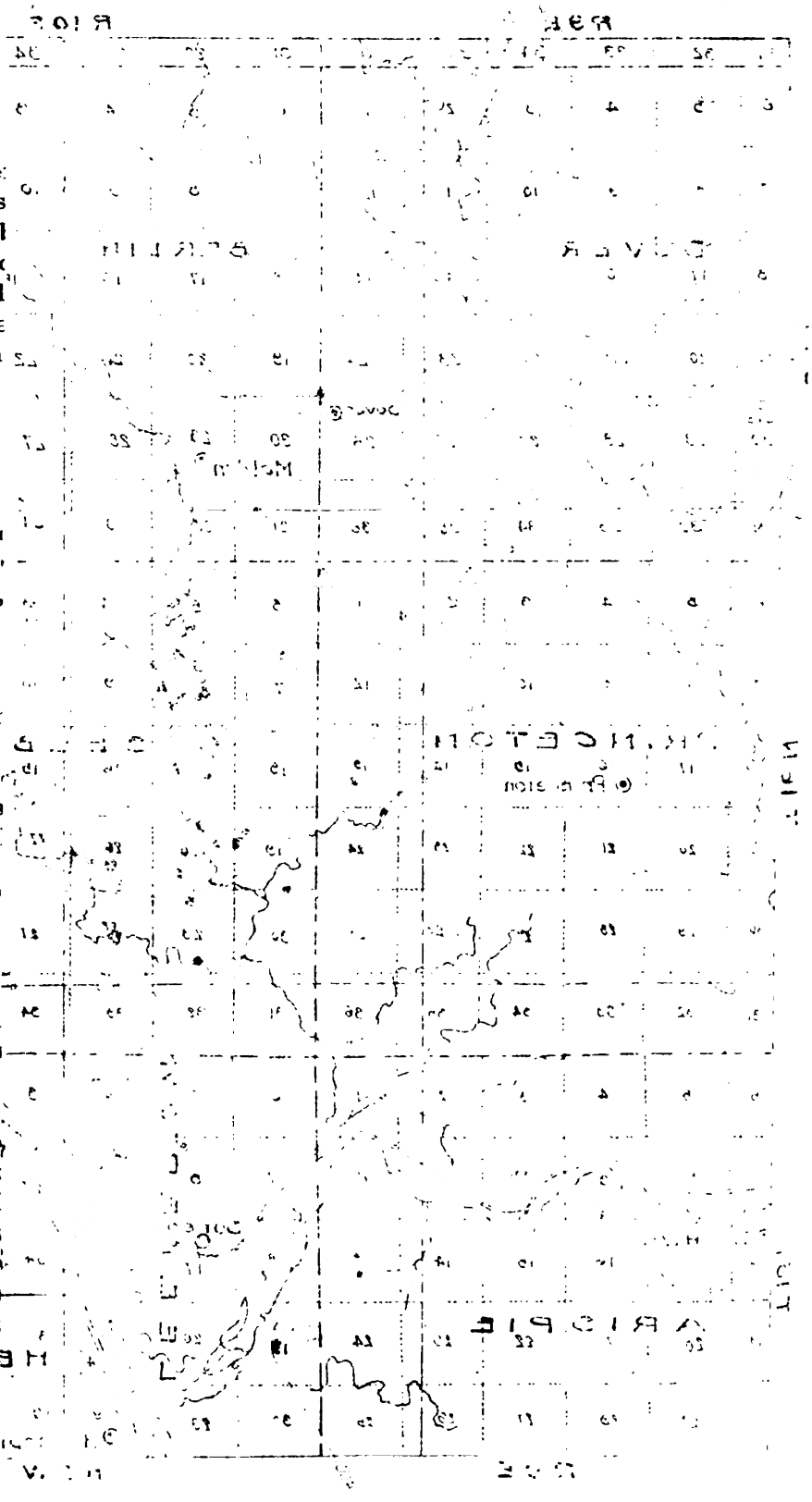

PLATE V.—Map showing the pre-

Illinois are most definitely known because of exposures along the Illinois bluffs. This valley had tributaries running northward across the present Illinois Valley at a number of places. One such valley crossed the Illinois just east of Spring Valley the cross-section of which is clearly indicated by the form of the rock surface outcropping in the Illinois bluff in sec. 26, Granville Township. South of the Illinois the rock surface exposed along the ravines slopes southward away from the present river bluff as though forming the north side of an earlier pre-glacial valley.

During the long periods of erosion that preceded Quaternary time, the stream gravels in the sluggish streams that must have prevailed in this area of relatively low elevation gradually acquired a higher and higher per cent of insoluble and hard constituents. Pebbles of quartz, flint, and the more resistant crystalline rock which had as an original source the crystalline area of Wisconsin and the flinty limestones of the intervening region were doubtless scattered rather widely over the Tertiary plain, as they are found commonly in the lower drifts. Concentration of these gravels from place to place along the pre-glacial valleys cut into the Tertiary plain, is thought to have been a normal erosion process following the late Tertiary rejuvenation.

QUATERNARY PERIOD

PLEISTOCENE EPOCH[1]

How early in Pleistocene time this area received deposits of glacial origin is not known. No drift of the earliest stage of glaciation, the Nebraskan, has been identified in Illinois, and the course of events in this area during this time are unknown. Presumably the erosion cycle inaugurated in late Tertiary time continued with little interruption until the first ice-sheet advanced over the area probably in Kansan time.

Pre-Illinoian Kansan (?) and Yarmouth (?) time.—In the early part of the Pleistocene epoch probably at the time of the second ice advance over the North American continent, which took place in Kansan time, this area lay under the ice sheet. The deposits left upon the retreat of the ice included glacial till, sand, and gravel. The meagerness of the information in regard to these deposits is such that little besides the probable presence of the ice sheet can be inferred. The deposits are found almost exclusively in the pre-glacial valleys. Subsequent pre-Illinoian erosion seems to have removed most of the drift from the upland.

The amelioration of the climate which caused the withdrawal of the Kansan ice sheet permitted the normal processes of vegetable and animal

[1] A somewhat different interpretation of the glacial drainage history has been presented by Carl O. Sauer in his "Geography of the Upper Illinois Valley and History of Development," Illinois State Geological Survey Bull. 27, 1916.

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growth to resume their activity and a long interval followed in which conditions not unlike those of the present prevailed. During this post-Kansan interglacial time, known as the Yarmouth stage, the surface of the drift was covered with vegetation, and the glacial deposits were subjected to considerable erosion.

Illinoian time.—The advance of the Illinoian ice from the Labrador center of glaciation was the next event of importance. As the drift deposited by this ice sheet is known to extend over most of the State except the extreme southern part, this region was undoubtedly entirely covered with ice. As the ice advanced it gathered up much of the material left by the Kansan glacier especially that in the more exposed places and mixed it with other debris it was carrying. In some places, however, the older drift was not greatly disturbed and the younger deposits were accumulated directly upon it.

Like the earlier drift the heaviest deposits of Illinoian age are found in the pre-glacial valleys, especially in the Hennepin quadrangle. They are less commonly found above an elevation of 620 feet than at lower elevations. This drift seems to have very effectively leveled up the pre-glacial valleys to a surface that probably was not greatly different from that of the late Tertiary plain.

Sangamon-Peorian time.—In the interglacial stage following Illinoian time the normal erosion processes were resumed. Valleys were formed in the Illinoian drift and in older rocks, and the weathering of the drift surface and the accumulation of humus in the soil progressed to a notable extent. Apparently forests occupied the lowlands somewhat the same as now, though the trees were more commonly coniferous than at present. One large swampy forested area seems to have been located in Hennepin quadrangle north of Bureau and Depue.

Toward the close of this stage there was accumulated over a large part of the area a deposit of silt and loess. Where the wind-blown material was deposited in water the material is commonly laminated and where swampy forest conditions prevailed the dust is more or less mixed with the partly decayed fragments of trees. Probably the preservation of the organic matter was more effectively accomplished by its burial by the loess. The fact that the forest beds are found below the loess seems to indicate that the climatic condition which made possible the existence of the loess was an important cause of the death of the trees. The swamps and wet places being finally dried up or buried, further deposits of the dust became entirely of eolian origin.

Some time, probably late in Sangamon-Peorian time or in early Wisconsin time before any Wisconsin outwash had reached this area, erosive processes were active. Shallow valleys were cut into the drift but rarely reached to the rock. These valleys seemed to trend north and south, conforming more

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in direction and position to the pre-glacial valleys than to those of the present. In places the Illinoian till was entirely removed and the stream cut into the Yarmouth (?) and Kansan (?) deposits and even into the rock. Such a pre-Wisconsin valley seems to have occupied approximately the position of the pre-glacial valley running across the present valley of the Illinois just east of Spring Valley. A similar valley cutting into the Illinoian till is filled by the gravels north of Bureau. This valley possibly continued southward approximately along the line of the present Illinois Valley with its west wall somewhat to the west of the valley bluff south of Bureau Creek.

Wisconsin time.—Wisconsin time is believed to have been inaugurated by the overwhelming of the valleys of the region by the outwash from the advancing ice sheet. The waters carrying the gravels seem to have advanced from the east since the gravels are commonly cross-bedded with beds dipping to the west. The streams seem to have been torrential and heavily laden with glacial debris of all sizes so that sorting was very imperfect. Masses of till rolled along the channels became rounded into boulder-like forms and were soon deposited with the gravel in irregularities in the surface over which the water was flowing. It is possible that much of the material was frozen rendering it more resistant to the attrition, which must have been very active. The outwash gravels that were spread out in advance of the ice again filled up the irregularities until a plain which at present has an elevation of 600 to 625 feet was formed over much of the area.

Over this plain formed by the outwash streams the Wisconsin ice sheet advanced, finally reaching a few miles west of the area where it built up a conspicuous terminal moraine, the Bloomington moraine. The front of the ice may have moved back and forth across this area a number of times before its final retreat. Its successive halts in its final recession from the region, however, are marked by small more or less loop-shaped recessional moraines which form the most conspicuous features of the uplands.

As the ice front melted back from the various moraines which it had at its margin there was a tendency for the formation of a marginal lake of greater or less size between the ice margin and the moraine. Such a marginal lake seems to have extended in front of the ice along the line of the Illinois Valley back of the moraine at Peoria. Its position seems to be indicated by the high bench found along many of the streams in the area at elevations exceeding 600 feet. This marginal lake or stream disappeared when the moraine was cut through and the waters thereby lowered to the inner valley. At this time possibly the Vermilion was the outlet of a marginal lake existing at the south margin of the ice in the vicinity of Kankakee, and possibly flowing at this high elevation acquired its course across the anticline, the rocks being still buried by the drift.

Another ice border or marginal lake seems to have been formed behind

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the Grand Ridge moraine after the ice had probably entirely left this area. This lake had at least two outlets. One was located in the SE. corner of sec. 36, Dimmick Township, and was tributary to Tomahawk Creek and Little Vermilion River. It was possibly at this time, if not before, that the Little Vermilion acquired its course across the anticline, as it was probably flowing at a high elevation and on the drift. Another outlet of this lake lay approximately in the position of the present Illinois but the spillway extended somewhat north of the valley so that part of it is preserved in the washed surface exposed in secs. 12, 13, and 14, La Salle Township. It is probable that considerable amounts of drift composing the moraine, which apparently extended across the valley, had to be removed before the rock surface was reached, after which it was some time before the definite position of the inner valley was determined. The Bloomington moraine at Peoria had probably long before been cut through and the process of valley deepening had already determined the position of the inner valley well up toward the anticline.

Following the draining of the lake behind the Grand Ridge moraine, erosion continued to deepen and develop the Illinois and tributary valleys. It is believed that at this time the valley from the bend southward, at least, was wider than it is at present and included the area occupied by the Hennepin terrace. The floor of the valley lay below the level of the Hennepin terrace, but how much below is not known. Possibly this stage marked a general retreat of the ice such as has been suggested as occurring between Early and Late Wisconsin times.

Later, probably when the ice readvanced over part of northern Illinois and reached possibly as near this region as the Marseilles moraine lying east of Fox River, there was another period of deposition of great quantities of outwash. Great deposits of gravel are found along Fox River, and these are thought to be the continuation of other deposits found along Illinois River south of Bureau. Contemporaneous with these deposits on the Illinois and its tributaries are similar gravels found in terraces along the Mississippi and smaller rivers in Illinois. At this time it is believed were accumulated the Hennepin gravels by which the previously excavated valley was filled up to an elevation of 560 to 575 feet above sea level, or approximately to the level represented by the top of the Hennepin terrace.

With the withdrawal of the ice from the Marseilles moraine to or beyond the Valparaiso moraine a lake formed behind the Marseilles moraine in the Morris Basin. As the water discharged from this lake was relatively free from detritus, active erosion took place in the valley below and the river entrenched itself in the valley floor.

From this time until the glacial marginal lakes in the Chicago area ceased to flow down the Illinois Valley the waters occupying the valley practically continuously had their source in lakes so that the stream was an effec-

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tive agent of erosion for a long time. As a result the valley was again cleaned out to a depth 60 to 90 feet below the present level of the valley floor east of the anticline. Apparently the erosion was not of sufficient duration to remove all the Hennepin gravels below the bend at Bureau, but if they ever existed above the bend they were completely removed, at least in this area.

RECENT EPOCH

The present physiographic cycle is believed to have begun when the Illinois Valley ceased to be the outlet of glacial Lake Chicago. The shrunken Illinois then occupied the lowest part of the outlet channel and possibly west of the anticline flowed at a much lower level than at present, but east of the fold at a slightly higher level. There was doubtless a great quickening of erosion along the lower part of the streams tributary to the Illinois, and where they had reached the rock narrow valleys were cut, which are in contrast with the wider valleys at a distance from the Illinois.

Subsequent history of the Illinois consists mainly in the filling of the valley below the La Salle anticline and the incision of the stream in the floor of the outlet channel above the anticline. As a result 60 to 90 feet of alluvium are now found in the river bottom south of La Salle, while to the east, especially in the Ottawa quadrangle, the Illinois flows between low cliffs of sandstone. This process of filling and cutting in the two parts of the Illinois is still in progress. Valleys tributary to the Illinois below the anticline, especially those on the Hennepin quadrangle, have also been built up, keeping pace with the filling along the master stream.

Except immediately bordering the streams there has probably been little change in the topography of the region since the glacial period. So far as known there has been no change in altitude.

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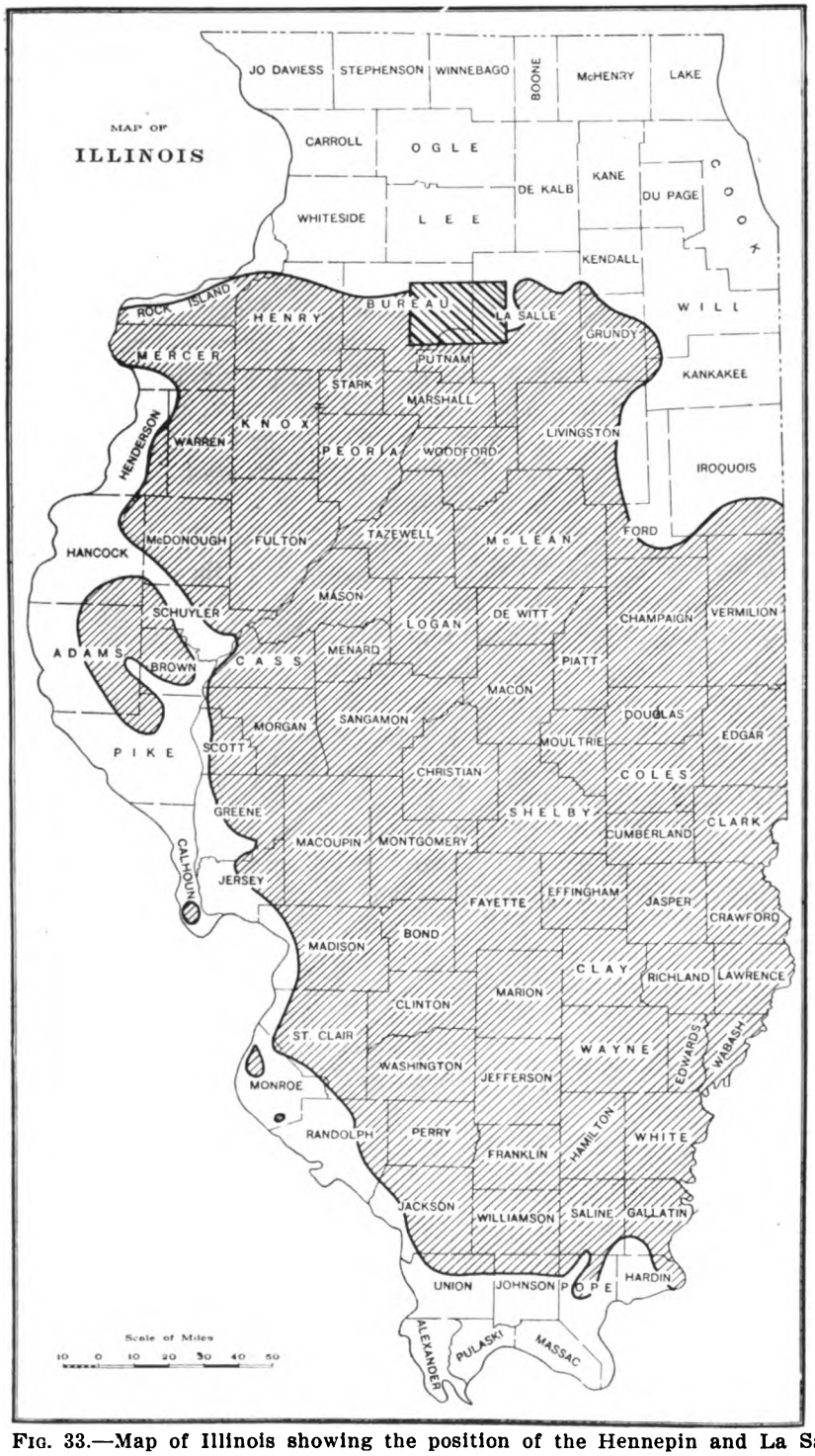

FIG. 33.—Map of Illinois showing the position of the Hennepin and La Salle quadrangles with reference to the extent of the "Coal Measures."

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CHAPTER VII—ECONOMIC GEOLOGY

The mineral resources of the La Salle and Hennepin quadrangles comprise coal, portland cement rock, hydraulic cement rock, sand and gravel, shale, clay, limestone, glass sand, and water. To these may be added the soil, which is the chief source of wealth in the area.

Coal

The quadrangles lie in the northern border of the eastern interior coal basin. (See fig. 33). Coal occurs at various horizons in the Pennsylvanian formations but the La Salle coal is of greater persistence than any of the other beds and is the only one now being mined.

POTTSVILLE COALS

West of the anticline Pottsville sediments contain some thin beds of coal of no commercial importance. One bed varying in thickness up to 22 inches is found 28 to 40 feet below the La Salle (No. 2) coal near Bureau, the interval increasing to the west. This bed in places is possibly reported as black shale. In the same area 20 to 25 feet below the coal just described there are here and there two thin beds of coal, the upper reaching a thickness of 14 inches in one place and the lower one 20 inches. The interval between these beds varies from 10 to 16 feet. East of the fold and along the anticline itself stringers of coaly matter have been noted in a few places in the clay underlying the La Salle (No. 2) coal. Such a thin seam occurs in the clay at the exposure near the Bottomly local bank along Vermilion River about three-fourths of a mile below Lowell.

CARBONDALE COALS

LA SALLE (NO. 2) COAL

Owing to its uniformity of character and the desirable mining conditions the La Salle (No. 2) or "Third Vein" coal is of great economic importance in considerable areas in La Salle, Bureau, Putnam, Grundy, and Will counties in northern Illinois. The coal district embracing these counties is known as the Longwall District, because of the method used in mining the coal. This bed underlies about one-half of the area of the Hennepin and La Salle quadrangles.

East of the anticline the La Salle coal is commonly either absent or not

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workable. The line of outcrop of the coal under the drift in Bureau County is indefinite. Here the cover consists mostly of a great thickness of glacial drift which renders the coal unminable. In Hennepin quadrangle and in the northwest quarter of La Salle quadrangle doubtful value attaches to the La Salle coal not overlain by McLeansboro formation, so that the area of workable coal in the former area possibly does not exceed one-quarter of the area of the quadrangle.

Along the area of folding there are many outcrops of coal and one mine. East of the fold the coal is mined by drifts and by stripping in connection with the excavation of fire clay or pottery clay. Practically all the available coal has been worked out along the outcrop north of Deer Park, but in general the operations have not extended far down the dip of the west side of the anticline. Mining on a large scale by means of a slope which follows the dipping beds is impracticable under ordinary mining conditions. Operation is very expensive, due to the steep angle of dip, the shattered condition of the roof, and the unstable character of the floor. The mine in the NE. ¼ SW. ¼ sec. 30, Deer Park Township, has by working down the dip, succeeded in carrying the slope to the bottom of the trough, but at the cost of great labor and by several changes in the methods of mining.

The physical character of the La Salle coal, including its thickness, its roof, and its floor, is described in Chapter IV in the description of the Carbondale formation. The following detailed observations made on the bed by the members of the State Geological Survey and Illinois Coal Mining Investigations show in greater detail the character of this coal, which is by far the most fully explored and best known in the area. Sixteen measured sections from 14 mines in the area are presented in graphic form in fig. 34.

SPRINGFIELD (NO. 5) COAL

The opportunities of investigating the Springfield (No. 5) or "Middle Vein" coal are limited to a few outcrops along the anticline and to the mine of the Matthiessen and Hegeler Zinc Company, located in the SW. ¼ sec. 11, La Salle Township. Previous to the disaster in 1909 this bed was also worked in the Cherry mine (in the SW. ¼ NW. ¼ sec. 27, Westfield Township), and a country bank in the center sec. 13, Princeton Township, mined this coal for a short time in 1909. The information regarding the coal elsewhere in the district is obtained from the records of coal borings and shafts.

The area underlain by the Springfield (No. 5) coal lies west of the La Salle anticline. Strata at this horizon outcrop along the sides of the preglacial valleys forming the Illinois-Rock system between Princeton and Seatonville and east of the present Illinois Valley south of the bend. The distribution of the coal as determined from drill holes and mines is shown in

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Plate VI. The holes in which the coal is reported missing are indicated by small circles.

Of the three important coal beds in the Hennepin and La Salle quadrangles the Springfield coal has the most irregular distribution. This may be due to lack of deposition or to erosion subsequent to deposition. In places the sandstone or sandy shale which lies in the section above the coal is continuous with the sandstone below the coal and cuts out the coal bed altogether. In other places it may cut out only part of the coal and in others only part of the

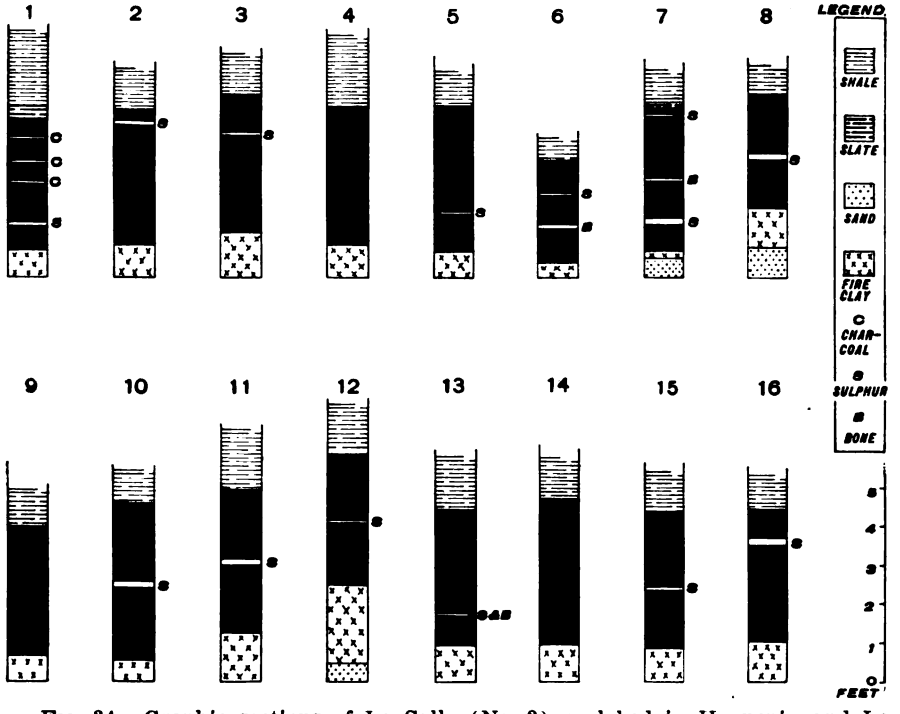

FIG. 34.—Graphic sections of La Salle (No. 2) coal bed in Hennepin and La Salle quadrangles.

normal roof. Locally the bed appears to lie in troughs between areas of sandstone, as is shown by the small body of coal that outcrops along Vermilion River about a mile below Lowell in sec. 8, Vermilion Township.

There is an area extending along the east side of La Salle County and continuing southward beyond the boundary of the quadrangles in which the Springfield coal has been found unworkable or absent (Plate VI). This area possibly swings more to the east north of Illinois River but the exact extent is not known sufficiently well to warrant very definite mapping. This coal was found to be unsatisfactory on the east side of the Cherry mine and on the

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west side of the Matthiesen and Hegeler mine at La Salle. It is reported that this bed was not workable at least on the north side of the mine of the Cahill Coal Co.,[1] in the SE. ¼ SW. ¼ sec. 16, Peru Township. It seems probable, therefore, that there is a considerable area lying between La Salle and Spring Valley and Cherry on the north where the bed is of doubtful economic value.

The physical character of the Springfield coal is described in Chapter IV, under the Carbondale formation. The accompanying graphic sections in fig. 35 are based upon measurement at seven localities in the area.

MCLEANSBORO COALS

STREATOR (NO. 7) COAL

The Streator coal is not at present being exploited in this area. In former years it was worked near La Salle, especially along the outcrop north

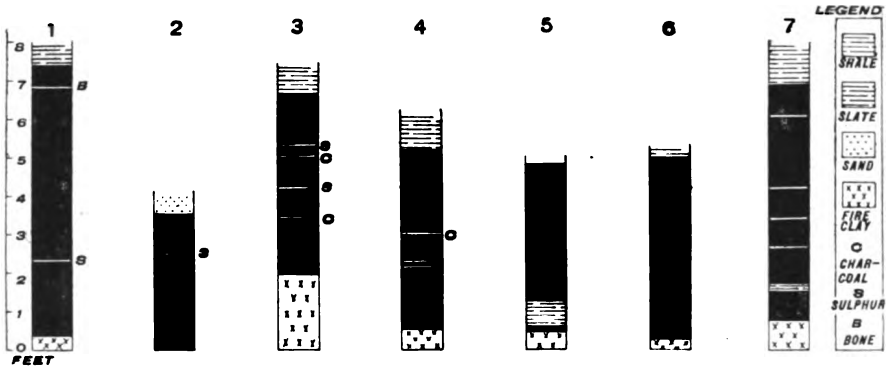

FIG. 35.—Graphic sections of Springfield (No. 5) and Streator (No. 7) coal beds in Hennepin and La Salle quadrangles.

of Illinois River. It has never been of great economic importance but probably will be of greater value in the future as the amount of minable coal decreases. The Matthiessen and Hegeler Zinc Company mines the clay below this bed but has never taken out this coal.

Little is known about the physical characteristics of the coal, since it has been seen only at one place. A brief description is given in Chapter IV, under the McLeansboro formation, and graphic sections are shown in fig. 35.

The Streator coal extends west from the anticline to the pre-glacial Rock-Illinois valley along the sides of which it outcrops. The area underlain by the coal in these quadrangles and adjacent areas is shown in Plate VI. The outcrop lies not far within and runs approximately parallel to the boundary between the Carbondale and McLeansboro formations. The area underlain

[1] Now the Illinois Zinc Company's No. 3 (Cahill) mine.

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in quad-

Thickness of coal	Number of bed
inches	
42	2
42	2
66	5
48	7
42	2
42	2
42	5
42	2
62	5
44	7
42	2
36	2
42	2
48	2
10	2
42	2
52	5
42	2
30	5
12	7
36	2
6	2
6	5
6	7
6	2
6	5
42	7

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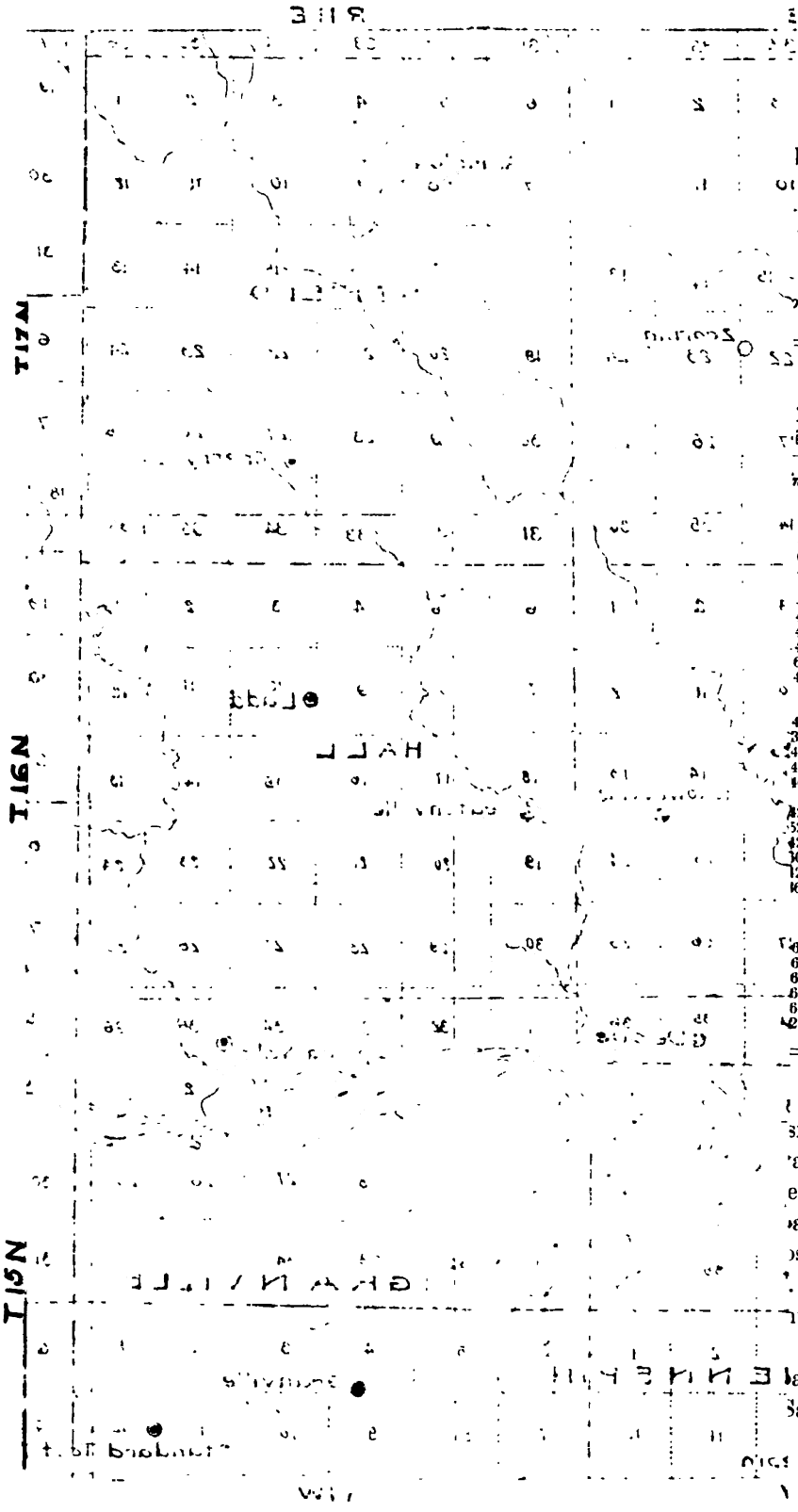

torope of Spiegfield (No. 5) coal and Streator (No. 7) coal on the Hen-

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PLATE VI.—Map showing the approxim

by his coal is less than that underlain by the La Salle coal and possibly less than that underlain by the Springfield coal.

The average thickness of the coal, as mentioned in Chapter IV, is 39 inches.

TABLE 1—*Names and locations of the shipping mines operating in the La Salle and Hennepin quadrangles and the depths, thicknesses, and elevations of the coal beds*

Name of company	Name of mine	Location					Elevation shaft	Depth to coal	Elevation of coal	Thickness of coal	Number of bed
		¼	¼	Sec.	T. N.	R. E.					
							Feet	*Feet*	*Feet*	*Inches*	
Bureau County											
Illinois Third Vein Coal Co.	Ladd	NW	SW	10	16	11	653	465	188	42	2
Spring Valley Coal Co.	No. 1	SW	SW	35	16	11	470	336	134	42	2
				....	....	....	.....	161	309	66	5
				....	....	....	.....	111	359	48	7
Spring Valley Coal Co.	No. 4 (idle) Seatonville	SE	SW	18	16	11	585	389	196	42	2
Spring Valley Coal Co.	No. 5 (Dalzell)	SW	SW	24	16	11	568	418	150	42	2
				....	....	....	.....	246	322	42	5
St. Paul Coal Co.	Cherry	SW	NW	27	17	11	694	486	208	42	2
				....	....	....	.....	316	378	62	5
				....	....	....	.....	271	423	44	7
La Salle County											
Illinois Zinc Co.	No. 3 (Cahill)	SE	SW	16	33	1	463	347	116	42	2
Illinois Zinc Co.	No. 1	SW	NE	30	33	2	500	244	276	36	2
La Salle County Carbon Coal Co.	La Salle	SE	SE	15	33	1	495	395	100	42	2
La Salle County Carbon Coal Co.	Union	NE	SE	16	33	1	503	386	117	48	2
La Salle County Carbon Coal Co.	No. 1	SE	SE	23	33	1	540	457	93	40	2
La Salle County Carbon Coal Co.	No. 5 (Cedar Point)	SW	SW	4	32	1	653	542	111	42	2
Matthiessen & Hegeler Zinc Co.	No. 1	NW	NW	14	33	1	572	307	265	52	5
Oglesby Coal Co.	Oglesby	NE	SW	25	33	1	562	457	105	42	2
				....	....	....	.....	300	262	60	5
				....	....	....	.....	246	316	42	7
Rutland Coal Co.	Rutland	NE	SW	18	29	2	ap 713	517	196	36	2
Putnam County											
B. F. Berry Coal Co.	Standard	SE	SE	11	32	(a)1	ap 680	497	183	36	2
				....	....	....	.....	321	359	6	5
				....	....	....	.....	284	396	36	7
St. Paul Coal Co.	Granville	NW	NE	8	32	(a)1	678	454	224	36	2
				....	....	....	.....	260	418	36	5
				....	....	....	.....	225	453	42	7

(a) Range West.

COAL BEDS ABOVE STREATOR (NO. 7) COAL

Two beds above the Streator (No. 7) coal have been worked to a small degree near the outcrop. They are not, however, of much economic value. The lowermost of these lies below the Spring Valley member of the McLeansboro formation and about 80 feet below the La Salle limestone. The coal is exposed in the NW. ¼ sec. 2, Hall Township, along Spring Creek opposite, mine No. 1 of the Spring Valley Coal Company, and in the NE. ¼ sec. 29, Granville Township. The coal is in the latter place about 16 inches in thickness but is thinner at Spring Valley.

About 30 feet above the La Salle limestone is another thin bed of coal 8 to 12 inches thick. Exposures of this coal are found (1) opposite La Salle where the road to Tonica runs up the bluff in the NW. ¼ NE. ¼ sec. 27,

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La Salle Township; (2) north of Peru in the NW. ¼ sec. 16, Peru Township; (3) along cuts on the Illinois Central Railroad in the SE. ¼ sec. 10, La Salle Township; and (4) above the wagon road in the NE. ¼ NW. ¼ sec. 26, of the same township. The bed is very persistent within a limited area.

MINING CONDITIONS

At present the commercial mines in the Hennepin and La Salle quadrangles are utilizing only the lower or La Salle coal. The region has in the past been one of relatively greater importance in the coal industry of the State than at present. In 1881 La Salle County led in output among the counties with 624,900 tons; in the next year it still held first place with over 2,000,000 tons, after which the center of production moved south until the county leading in 1907 and 1908 is at the extreme southern end of the coal field. The production of coal in 1914 in Bureau County was 1,284,311 tons; in La Salle County, 1,279,592 tons; and in Putnam County, 605,863 tons. Except for La Salle County the production from these counties is practically all from mines within the areas of the quadrangles.

A list of shipping mines operating in the Hennepin and La Salle quadrangles is to be found in Table I. The company names and locations, together with depths, thicknesses, and elevations of the coal beds, are given for each mine.

CHEMICAL ANALYSES

Samples have been collected from all but one of the commercial mines in the area and from the mines operated by the Illinois Zinc Company and the Matthiessen and Hegeler Zinc Company. The results of the analyses of these samples are listed below. Except as otherwise indicated the analyses were made for the State Geological Survey under the direction of Prof. S. W. Parr.

TABLE 2—*Proximate analyses of coals in La Salle and Hennepin quadrangles*
[La Salle (No. 2) coal unless otherwise noted]

Laboratory No. (*a*)	Form of analysis (*b*)	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Carbon as CO_2	British thermal units
1741 U. S.	A	13.87	37.26	38.56	10.31	3.44	.....	10985
1742 U. S.	A	15.55	36.21	40.66	7.58	3.01	.....	.....
1765	A	14.03	40.65	36.92	8.40	2.89	.....	11204
	B	.....	47.28	42.95	9.77	3.36	.....	13033
1779 U. S.	A	12.39	36.89	41.80	8.92	3.92	Carbon 61.29	11399
4060	A	12.86	38.96	39.06	9.12	4.40	.52	11289
	B	.....	44.71	45.97	9.32	4.49	.59	12954
4061	A	16.41	36.68	33.57	13.34	3.36	1.84	10101
	B	.....	43.88	40.16	15.96	4.02	2.20	12085
4062	A	15.72	38.01	37.48	8.79	3.64	.83	10909
	B	.....	45.09	44.48	10.43	3.71	.98	12943
4063	A	15.82	38.60	36.19	9.39	3.54	.54	10825
	B	.....	45.85	43.00	11.15	3.60	.64	12859

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Table 2—Concluded

Laboratory No. (*a*)	Form of analysis (*b*)	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Carbon as CO_2	British thermal units
4064	A	13.71	39.56	39.13	7.60	3.76	.48	11439
	B	.....	45.85	45.35	8.80	4.36	.56	13256
4065	A	15.12	38.01	38.78	8.09	3.54	.67	11099
	B	.....	44.77	45.71	9.52	4.17	.78	13076
4067	A	13.06	39.21	38.02	9.71	4.17	.28	11220
	B	.....	45.10	43.74	11.16	4.26	.32	12905
4068	A	14.79	37.78	38.51	8.92	3.68	.61	11120
	B	.....	44.34	45.20	10.46	4.32	.71	13050
5388 5389 5390	A B	14.60	39.88 46.70	36.97 43.29	8.55 10.01	3.97 4.65	.81 .95	10904 12768
5306 5307 5311	A B	15.05	39.76 46.80	37.00 43.56	8.19 9.64	3.30 3.88	.59 .69	10899 12830
5351 5352 5353	A B	17.45	38.98 47.22	34.52 41.82	9.04 10.95	3.18 3.85	1.49 1.81	10391 12587
1764	A	15.61	36.86	39.44	8.09	3.62	....	10977
	B	.....	43.68	46.73	9.59	4.29	....	13008
1769	A	15.99	38.92	37.56	7.53	3.39	....	11082
	B	.....	46.33	44.71	8.96	4.04	....	13191
2617	A	16.00	36.19	38.05	9.76	2.96	....	10781
	B	.....	43.09	45.29	11.62	3.53	....	12834
4069	A	14.66	36.86	40.67	7.81	2.82	.42	11316
	B	.....	43.19	47.66	9.15	3.31	.50	13260
4070	A	16.62	36.56	37.29	9.53	2.94	.87	10725
	B	.....	43.84	44.73	11.43	3.52	1.04	12863
4071	A	15.82	36.97	39.23	7.98	3.13	.34	11024
	B	.....	43.92	47.93	8.15	3.72	.41	13096
4389	A	14.40	38.75	39.10	7.75	3.73	.58	10933
	B	.....	45.27	45.66	9.07	4.36	.68	12771
4390	A	16.94	37.72	38.31	7.03	3.72	.67	10603
	B	.....	45.42	46.12	8.46	4.49	.81	12766
5324 5325 5326	A B	16.19	37.79 45.06	38.06 45.40	8.00 9.54	3.24 3.86	.82 .98	10787 12869
5348 5349 5350	A B	16.50	38.48 46.02	37.59 45.02	7.43 8.90	2.40 2.90	1.16 1.39	10868 13108
5312 5313 5314	A B	16.13	38.82 46.28	38.36 45.74	6.69 7.98	3.15 3.76	.70 .84	10994 13108
2638	A	14.95	37.91	39.58	7.50	2.89	....	11214
	B	.....	44.66	46.53	8.81	3.39	....	13185
4072	A	15.20	37.00	38.77	9.03	3.81	....	10937
	B	.....	43.63	45.72	10.65	4.49	....	12897
Extra (*c*)	A	14.76	34.26	41.33	9.65	3.38	....	10672
	B	.....	40.19	48.49	11.32	3.97	....	12543
2622 (*c*)	A	17.31	34.81	39.11	8.77	3.38	....	10052
	B	.....	42.09	47.30	10.61	4.09	....	12699

(*a*) Numbers are those of the State Geological Survey unless otherwise noted
(*b*) A—As received; B—Moisture free
(*c*) No. 5 coal

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Clay and Shale

The workable clays of commercial value in these quadrangles are confined to the deposits of Pennsylvanian and Quaternary age.

PENNSYLVANIAN CLAY AND SHALE

POTTSVILLE CLAY

Pottsville clay of commercial value is found in small areas along Little and Big Vermilion rivers and along Illinois River bluff in secs. 20 and 21, Deer Park Township. The clay is being worked in three localities—at Lowell, on the south bluff of Illinois River opposite Utica, and north of Deer Park in the NW. ¼ SE. ¼ sec. 30. Other localities where the clay is possibly of workable thickness are at the mouth of and at various places along Deer Park Canyon, along the ravine immediately south of the canyon, and along the valley in the N. ½ sec. 5, Vermilion Township. The clay outcrops at a number of places north of Illinois River, but it is nowhere of sufficient thickness to be valuable.

This clay is most characteristically developed in this area on a floor of Galena-Platteville limestone or dolomite and often contains residual flints derived from the limestone. Where the clay is practically flat-lying and has weathered, it develops plastic properties and alters from its usual gray or bluish color to yellow.

At Lowell the clay underlies a terrace below the top of which lies the La Salle (No. 2) coal. The limestone upon which the clay has been deposited has a very uneven surface so that the quantity of material available is difficult to determine. The thickness is known to be as great as 20 feet and in other places it is practically absent.

The clay at Utica underlies the high bench south of the bluff line and is covered toward the south by the La Salle coal. About one-half mile south of the bluff line the surface rises rapidly and the clay becomes covered with 20 feet or more of rock or drift. The clays at Utica like those at Lowell lie upon an irregular surface of Galena-Platteville dolomite, but the relief of the underlying rock is less than at Lowell and the corresponding variations in thickness of the clay are less. The clay where it underlies the coal varies from about 6 to 20 feet, the average thickness being reported as 12 feet.

The clay at the clay mine north of Deer Park near the Black Hollow mine (Illinois Zinc Company), differs from that already described in being separated into two beds by a lenticular sandstone and a discontinuous bed of pisolitic limestone boulders. The entire section from the La Salle coal to the pre-Carboniferous surface is about as thick as elsewhere but the amount of clay is less because of the presence of the sandstone. About 5 feet of clay are commonly found above the sandstone and this is the bed that is mined. Concerning the lower bed little is known.

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The floor clay in the mines on the quadrangle working the La Salle coal is of probable commercial value along and adjacent to the anticline. In the Black Hollow mine and on the east side of the old Rockwell mine located in the SE. ¼ sec. 14, La Salle Township, and in the east side of the Oglesby shaft located in the SW. ¼ sec. 25, of the same township, the clay is thick and is probably similar to that found at Utica and Lowell. As much as 18 to 20 feet of clay is known to lie below the coal in some of these mines, but in general little is known in regard to the thickness of the clay. There has been little or no exploitation of this formation where it occurs in the mines.

West of the immediate vicinity of the anticline the clay is thin or absent and apparently of little value in the manufacture of clay products.

The following is an analysis of the clay from a pit south of Utica:

Analyses of the Pottsville clay from a pit south of the Illinois Valley opposite Utica (a)

Sample.	Moisture	Volatile	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	Total per cent
Blue clay	2.37	8.84	54.80	1.70	29.44	0.82	97.97
Yellow clay	1.76	9.18	55.86	3.09	27.09	1.06	98.04

(a) Purdy, R. C., and DeWolf, F.W., Preliminary investigation of Illinois fire clay, Illinois State Geological Survey Bull. 4, p. 166, 1907

The sample of blue clay was slightly bent and showed a glassy fracture at cone 22 under reducing conditions. Under oxidizing conditions it was still straight though not carried beyond the vitrification point at cone 30. The very high period of fusion indicates that this clay may be first class for fire brick. The yellow clay was not vitrified at cone 21 but began to bend at cone 30. This clay has been used by the State Survey in making saggers and frit crucibles and found to be equal in every respect to the Christy fire clay of St. Louis.

The Pottsville clay varies somewhat in quality from place to place and its uses vary accordingly. The clay at Lowell has been used for many years in the manufacture of pottery; at the other places the clay is shipped raw for use as a low grade fire clay by the steel companies. Farther east on the Ottawa quadrangle where the clay is more siliceous it is used extensively in the manufacture of fireproofing. This is one of the most valuable clays in northern Illinois.

CARBONDALE AND MCLEANSBORO CLAYS AND SHALES

Between the La Salle and Springfield coals no shale is at present being used in the manufacture of clay products although the roof of the La Salle coal, and a thick, brown, micaceous shale found above and below the Springfield coal and the associated strata have been used in the manufacture of common brick. There seems to be great quantities of material suitable for the

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manufacture of this grade of brick. Brown, micaceous shales similar to those above and below the Springfield coal are also locally found above the roof shale of the Streator coal.

The clay below the Streator (No. 7) coal is one of the important sources of raw clay in the area. It is now mined by the Matthiessen and Hegeler Zinc Company in their shaft at La Salle. It has recently been worked by a drift mine in the SW. ¼ NE. ¼ sec. 31, Deer Park Township, near Deer Park, and was at one time mined in the Ladd shaft. There are exposures of the clay in the ravine west of Split Rock, sec. 12, La Salle Township, and along the west bluff of Little Vermilion River for 2 or 3 miles above the gorge. In the Matthiessen and Hegeler Zinc Company's mine this fire clay is thought to be 20 to 23 feet thick but only the upper 6 feet is mined, as the lower part contains sulphur balls. This clay is used by the Zinc Company in the manufacture of retorts after being mixed with clay from St. Louis.

Below the La Salle limestone there are about 13 feet of shale the upper part of which is used by the two cement plants south of the Illinois in the manufacture of Portland cement.

At the west end of the mill of the Marquette Cement Co. in the NW. ¼ SE. ¼ sec. 36, T. 33 N., R. 1 E., the strata are well exposed for about 20 feet below the La Salle limestone.

Section of the strata below the La Salle limestone on the property of the Marquette Cement Co., in sec. 36, T. 33 N., R. 1 E.

Description	Thickness		Depth	
	Feet	*Inches*	*Feet*	*Inches*
McLeansboro formation:				
Limestone (La Salle) 15 feet +	..	..	..	..
Shale, greenish	..	8	..	8
Shale, black and fissile at the top, gray towards the bottom	5	6	6	2
Coal	..	2	6	4
Shale, gray to green; somewhat concretionary	7	6	13	10
Limestone, heavy bedded earthy	4	..	17	10
Shale, yellowish green	5	..	22	10

The shale is divided into two beds of about equal thickness by a thin seam of coal. Toward the west side of the La Salle quadrangle this shale outcrops along many of the ravines. The only use to which this stratum is put at present is in cement manufacture.

West of Peru is found a shale of some economic value above the black shale marking the base of the La Salle formation and the *Productus*-bearing, siliceous limestone. Such a shale bed has been recently developed in the east part of the city of Peru in the NW. ¼ sec. 20, T. 33 N., R. 1 E., where it was used in the manufacture of drain tile.

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In a small area north and south of the Illinois in and opposite La Salle and Peru a series of variegated shales of economic value are found near the top of the valley bluff. The distribution of this clay is extremely limited, it probably being confined to secs. 8, 9, 16, 17, 28 and 29, Peru Township, and secs. 10, 15, 25, 26, 27 and 36, La Salle Township. A small area in the W. ½ sec. 6, Vermilion Township, and the E. ½ sec. 1, Eden Township, along Bailey Creek is also underlain by similar shales.

The section near Peru is given below. In this section numbers 1 to 6 inclusive are used in the manufacture of clay products. Strata numbered 5 and 6 comprise the upper bed. This shale is used for making sidewalk brick. The middle bed (No. 4), a yellowish lumpy or joint clay without laminae or bedding planes is reported to be suitable for making paving brick, though it is not used for that purpose. The lower bed (Nos. 1 to 3), is a bluish laminated clay suitable for common brick.

Section of the shale about 60 feet above the La Salle limestone between La Salle and Peru, in SE. ¼ NE. ¼ sec 16, Peru Township

Suface elevation, 592 feet

Description	Thickness		Depth	
	Feet	*Inches*	*Feet*	*Inches*
12. Loess, light yellow	4	..	4	..
11. Shale, yellowish	2	..	6	..
10. Shale, yellow to dark gray	2	..	8	..
9. Shale, reddish	1	..	9	..
8. Shale, nodular, calcareous, gray	3	6	12	6
7. Shale, reddish	1	6	14	..
6. Shale, gray	7	..	21	..
5. Shale, gray, with a thin black shale cover	1	6	22	6
4. Shale, yellow, with a squarish joint structure	6	..	28	..
3. Shale, lavender color, mixed with brown and gray shale	2	6	31	..
2. Shale, red	2	..	33	..
1. Shale, gray	..	9	33	9

An analysis of the lower clay in the pit at Peru is given below.

Analysis of the shale in the lower bed of the clay pit located in the E. ½ sec. 16, T. 33 N., R. 1 E., Peru, Illinois (a)

SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	K_2O and Na_2O	Ignition	H_2O
56.56	12.64	13.56	2.75	2.22	4.82	6.02	3.7

(a) Rolfe, C. W., and others, Paving brick and paving brick clays of Illinois: Ill. State Geol. Survey Bull. 9, p. 285, 1908

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QUATERNARY CLAYS

The use of Quaternary clay is confined to the surface loess. Just north of the north edge of the La Salle quadrangle at Triumph is a tile plant which utilizes the surface loess such as is found over large areas in both quadrangles between the morainic areas. At this place all but the upper 4 inches of 4½ feet of loess is used. The black humus extends downward about 1½ feet. Below this is a subsoil of fine clay containing no stones. A bed of sand and gravel is reported underlying this clay at irregular intervals, in some places rising within 4 feet of the surface.

Two tile plants are operated in the vicinity of Princeton, one in the SW. ¼ and one in the NW. ¼ sec. 17, T. 16 N., R. 9 E., where conditions are similar to those at Triumph.

CEMENT MATERIAL

NATURAL CEMENT

The natural cement rock is of "Lower Magnesian" age and is found along the north bluff of the Illinois Valley between La Salle and Utica, for one-half mile north along Pecumsaugan Creek, and in the river bottoms in sec. 17, T. 33 N., R. 2 E. There are two beds of cement rock, the lower of which is exposed at the base of the cliff at the mouth of Pecumsaugan Creek and the upper about 20 feet above. These beds dip eastward at such a rate that in one mile the upper bed is about 4 feet above the base of the cliff. Still farther east in sec. 7, Utica Township, the upper level is quarried in the floor of the Illinois Valley and the lower one is reached by a vertical shaft. Except for the single quarry described the stone has been obtained by mining.

The rock is a fine-grained siliceous to argillaceous dolomitic limestone, light gray to buff, and shows irregular laminations due to alternation of hard and soft layers. It weathers to a rather smooth surface and is rather soft.

The upper "vein" is 6½ to 7 feet in thickness and the lower from 8 to 20 feet thick with locally a band of sandstone 1 to 3 feet thick midway in the "vein." Toward the east the lower bed is thicker and the interval between the two beds greater than along Pecumsaugan Creek. The sandstone impurity in the lower bed seems to be confined to the eastward occurrences.

In previous years this rock has been extensively utilized in the manufacture of hydraulic or natural cement. Within the last 5 years two large mills have been dismantled but a third is still active in the vicinity of Utica.

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TABLE 3—*Analyses of the Utica natural cement rock*

	1	2	3	4	5	6	7
Silica	29.84	27.70	26.46	11.89	27.60	15.02	14.42
Iron	1.52	1.41	1.36	1.35	.80	8.20	11.34
Alumina	3.36	2.33	3.39	11.61	10.60	.....	.....
Lime	30.17	29.94	30.30	29.51	33.04	25.40	26.12
Magnesia	20.69	20.01	20.81	20.38	17.26	12.50	9.82
Volatile matter	10.24	16.03	13.38	.....	.....	38.54	38.70
	95.82	97.52	95.70	.....	.....	99.66	100.50

1, 2, 3, C. B. Lihme, Analyst. 4, 5, Quoted from Eckels: "Cements, Limes, Plasters." 6. Upper bed. Analyzed by State Geological Survey. 7. Lower bed. Analyzed by State Geological Survey

PORTLAND CEMENT

The limestone outcropping in this area and used for the manufacture of Portland cement is the La Salle limestone. Its distribution is shown on the economic geology sheet. The detailed description of the formation is given

TABLE 4—*Analyses of the La Salle limestone*

SiO_2	Fe_2O_3 and Al_2O_3	CaO	MgO	Volatile matter	Source of the samples analyzed
6.06	3.92	49.46	.91	39.06	Chicago P. C. Co.
8.20	1.30	49.37	.85	39.72	Marquette P. C. Co.
7.54	3.43	45.57	4.36	39.57	German-American P. C. Co.
5.06	2.52	48.29	3.66	41.05	German-American P. C. Co.
13.89	2.61	45.91	1.00	36.82	German-American P. C. Co.
5.43	1.43	52.02	1.11	40.24	German-American P. C. Co.
6.72	5.92	47.84	.66	40.20	NW. ¼ sec. 11, T. 33 N., R. 1 E.
11.10	7.84	43.46	1.16	37.38	SE. ¼ sec. 34, T. 34 N., R. 1 E.
4.92	3.08	50.52	.89	41.36	Near La Salle, upper bed.
22.26	6.86	36.62	1.91	33.28	Near La Salle, upper part of lower bed.
17.76	9.56	36.64	2.42	34.36	Near La Salle, lower part of lower bed.
4.43	2.86	51.32	.59	41.92	Chicago P. C. Co., upper bed.
9.62	5.56	46.08	.74	39.16	Chicago P. C. Co., lower bed.
2.66	1.96	52.32	.58	38.54	Bailey's Falls, upper bed.
15.24	7.58	41.54	1.14	38.80	Bailey's Falls, lower bed.
2.88	2.24	51.78	.69	42.06	Sec. 14, T. 33 N., R. 1 E., upper bed.
8.78	4.76	46.08	1.96	39.26	Sec. 14, T. 33 N., R. 1 E., upper part of lower bed.
10.34	4.40	45.58	1.38	37.88	Sec. 14, T. 33 N., R. 1 E., lower part of lower bed.
1.98	1.56	53.32	.75	42.66	Marquette P. C. Co., roof rock.
7.94	4.80	48.02	.68	39.48	Marquette P. C. Co., upper part of lower bed.
8.24	3.40	47.72	1.31	38.90	Marquette P. C. Co., lower part of lower bed.

The first six analyses are taken from Eckel: "Cement, limes and plasters." The remaining fifteen are analyses by the State Survey of samples collected by the members.

in the section under the description of the McLeansboro formation in Chapter IV.

Cement mills are located at three points along the outcrop, viz: on the east side of the Little Vermilion opposite La Salle, in the SE. ¼ sec. 25, and in the NE. ¼ sec. 36, La Salle Township. This is one of the important industries of the region.

The treatment of the rock and strata used depends upon the character of the rock. Where the limestone is very argillaceous, as it is in the quarry

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north of the Illinois, the rock is a natural "mix" and requires little or no additional argillaceous matter. South of the river, however, there is less argillaceous material present and recourse is had to the dark shale underlying the limestone. This is mixed and ground up with the limestone giving the "mix" a proper proportion for burning.

Limestone

Limestone for building material is in very little demand in this region. The La Salle limestone has in the past been the source of considerable building stone, but little is used at present. Near Hicks Corners the *Productus*-bearing siliceous limestone has been quarried on a small scale. Neither of these beds yields a building stone of great value. The La Salle limestone has likewise been used to a small degree for crushed stone by the electric railroad. A small stone-crushing plant was operated for several years prior to 1910 along the bluff on the line between secs. 13 and 14, La Salle Township. Large areas of limestone on the quadrangle are available as a source of this material.

Sandstone

The St. Peter sandstone is an important source of glass and other fine sands. There are no sand quarries within the area, probably because all the available sand outcrops within the corporation limits of Utica. There is, however, a great amount of the sandstone that never has been worked along the south bluff of Illinois River Valley south of Utica. This sand will probably become of economic importance should water transportation become practicable. Cheap shipping facilities are absolutely essential, the quality of the sand being a secondary item.

The only sandstone hard enough to serve for building stone is the hard, ferruginous ledge of Pottsville sandstone found frequently along the Little Vermilion River and its tributaries entering from the east.

Sand and Gravel

The deposits of sand and gravel within the area of the quadrangles are of very great amount. The most extensive deposit is that underlying the Hennepin terrace—the so-called Hennepin gravel—to a depth varying from 50 to 100 feet, over an area of 6 or 7 square miles. Other deposits of gravel are found in the following localities:

(1) Along the bluff of Illinois River between Bureau and Depue; (2) in sec. 25, Arispie Township; (3) along Bureau Creek west of Princeton and northwest of Bureau; (4) east of Depue in sec. 36, Selby Township; (5) along the east side of Spring Creek in sec. 36, Hall Township; (6) south of Spring Valley, sec. 26, Granville Township; (7) east of La Salle along Ver-

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milion River, secs. 11 and 14, La Salle Township; (8) in sec. 32, Waltham Township, and in the adjoining section south; (9) north of Utica, secs. 4 and 9, Utica Township; (10) northwest of Deer Park in NW. ¼ sec. 30, Deer Park Township; (11) in SW. ¼ sec. 31 of the same township; (12) in SE. ¼ sec. 5, Utica Township; (13) in SE. ¼ sec. 25, La Salle Township; (14) and in NE. ¼ sec. 26, of the same township. There are many smaller areas of gravel in the till and the outwash plains between the morainic ridges, especially on the west side of these ridges. The sand and gravel of this area is in general rather coarse and poorly sorted, typical of the outwash. Other gravels, more often of a reddish color, are found in the quadrangles, but with an overburden that renders them difficult to work.

Some gravel is excavated from the stream channels in various parts of the quadrangles and from the Illinois River when it is low.

Large amounts of gravel have been taken from the various deposits and used for concrete, road metal, railroad ballast and filling, and other varied uses to which gravel is put.

Oil and Gas

INDURATED STRATA

Although this area is located on the most important anticlinal structure in the State there seems to have been no accumulation of oil or gas in the rocks affected by the folding within this area. None of the numerous artesian wells drilled directly on the fold on either side has encountered oil or gas. The most promising locality has been thought to be in the vicinity of Lowell, but recent exploration has shown the improbability of productiveness in that region.

GAS IN THE DRIFT

Many gas wells in the drift are found in those parts of the quadrangles underlain by thick drift. The productive area is almost entirely confined to the Hennepin quadrangle. On the economic geology sheet the location of gas wells is shown by small green circles.

The gas is used by the owners of the wells for private consumption in lighting and sometimes in heating their houses, the supply not being sufficient to pipe to neighboring farms or villages. So slight is the pressure in many wells that changes in the atmospheric pressure manifested by changes in wind direction cause fluctuation in the flow or even cause it to cease altogether.

As has been shown under Descriptive Geology, the source of the gas is interglacial or sub-glacial "forest beds" or soils lying between or below more or less impervious tills or silt beds.

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Water Resources

SURFACE WATER

The country is well watered. Illinois River, Pecumsaugan Creek, Big and Little Vermilion rivers, Cedar Creek, Spring Creek, Negro Creek, Allforks Creek, and Bureau Creek are all permanent streams.

The water of none of the streams is used for municipal supply by any of the cities of the area, but the water from Illinois River and also from the Little and Big Vermilion rivers is used by various manufacturing establishments. The large amount of sewage entering the river from the drainage canal will probably make the people hesitate to undertake the purification of the Illinois River water for domestic use. A more immediate source of contamination is the sewage of the cities on the quadrangle.

UNDERGROUND WATER

SPRINGS

SPRINGS IN THE DRIFT

Springs in the drift are found frequently where thick beds of Wisconsin gravel overlie earlier impervious till, as along Illinois River bluffs between Depue and Bureau. One of the best examples is Big Springs located near the center of sec. 4, Leepertown Township. A similar spring horizon occurs south of Spring Valley in sec. 26, Granville, though in this case the gravel probably rests directly upon the "Coal Measures."

In those valleys where both Wisconsin and Illinoian till occur springs generally help to indicate the line of contact, the lower till being very indurated and usually separated from the upper till by a bed of gravel.

In addition to these occurrences of springs small lenses of gravel interbedded in the till sheet if cut in two by erosion may afford small springs, such as are found occasionally in various parts of the quadrangle. Such springs, like the shallow wells, can readily become contaminated.

SPRINGS IN THE ROCK

Spring horizons are found between the La Salle limestone and the underlying black fissile shale. A similar spring horizon exists about 20 feet lower above another black shale. This is the horizon of the spring along the C. & N. W. R. R. in NW. ¼ sec. 35, Hall Township, in the northeast part of Spring Valley where there was formerly a small bath house.

The peculiar landslip topography characteristic of Illinois River bluffs seems to be a result at least partly of these occasional water bearing horizons. The ground water from a considerable area back from the bluff obtains outlet here and soaking over the underlying shales renders them slippery and inse-

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cure, resulting finally in their actual separation from the main body of rock. Railroads built along these bluffs will probably always be inconvenienced by the land slips. This same black shale turns the water and forms springs all along the cliffs of the Illinois River west of Vermilion River as far as Marquette. The contact between the St. Peter sandstone and the Lower Magnesian limestone is another marked spring horizon. One of the best springs on the quadrangle is found at this horizon or near it in Spring Dell, NE. ¼

FIG. 36.—Fissure in the St. Peter sandstone parallel to and near the crest of the anticline. Several springs issue from this crack.

sec. 13, La Salle Township. Springs have been opened likewise by the mining of the Lower Magnesian limestone at the mouth of Pecumsaugan Creek.

In the vicinity of Deer Park there are two springs, one of which certainly and the other of which possibly arises from vertical cracks in the rock. One of the springs is located in the basin at the foot of the main falls in Deer Park canyon in the NW. ¼ sec. 32, Deer Park Township. This spring bubbles up through the sand, the actual source being obscured. In Clark's Ravine

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which empties into Vermilion River about 100 feet south of the mouth of Deer Park Canyon there is a vertical fissure in the floor of the ravine running N. 30 degrees E. (see fig. 36). The water issuing from the fissure has a distinct odor of hydrogen sulphide. Generally the areas underlain by St. Peter sandstone are devoid of springs.

WATER TABLE

Underground water level fluctuates with the surface contours. The water table in the intermorainic areas is near the surface. It is only within recent years that considerable areas of swamp land have been drained and thereby made arable. The upper part of the valleys of Tomahawk, Spring, Negro, Brush, East Bureau, Lime, Allforks, and Cedar creeks all bear evidence in the peaty condition of the soil of having been swamps until recently. The small lake bed west of Arlington was drained during 1912 and a crop started on part of the area. Over the morainic ridges the water table falls twenty feet or more below the surface, though the surface of the ridge may rise 100 feet or more above the till plains.

The circulation of the ground water in the ridges is less rapid than in the intermorainic areas because of the greater percentage of permeable sandy layers in the latter areas.

WELLS IN THE DRIFT AND THE ALLUVIUM

Shallow wells 75 feet and less in depth that yield a supply sufficient for a small farm or a pasture are confined to the intermorainic areas or to the valley flats. The depth of water in such a well fluctuates considerably with the seasons, in mid-summer being often very low. Such shallow wells are probably the most common wells in the area. The source of the water is usually a layer of "quicksand" or gravel. Certain areas, as in the vicinity of Triumph, have a widespread local aquifer to which most of the wells of the community go. A similar condition obtains in Eden Township and in the northeast portion of Utica Township shown on the map. Failure to strike sandy or porous layers at a shallow depth necessitates a deeper well to a lower sand or to a sufficient depth to obtain a requisite amount of seepage from the clay. Wells depending on shallow supply are accordingly deeper along the ridges than between them.

The depth of 75 feet is arbitrarily taken as the limit of the shallow wells. Wells of that depth or less depend largely upon the surface water supply and are for the most part in the same till sheet in which they start. The deep wells in the drift, 75 to 250 feet in depth, are located for the most part in the Hennepin quadrangle and are distributed along the Princeton-Dover ridge, and in the area to the north, along the Arlington moraine, on the upland in

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Arispie Township, on the Hennepin terrace, and the adjacent upland in the southeastern corner of the quadrangle. The demand of these arises from the unsatisfactory supply obtained from wells depending upon surface seepage, and the occurrence of sand and gravel beds along the contact of the three drifts of the area at the top and bottom of the main till sheets. The description of these till sheets has been given in Chapter IV. The contacts between the tills lie about 100 feet apart at elevations averaging 500 and 400 feet above sea level respectively for the upper and lower contact. The deeper wells will be found to reach or nearly reach one or the other of these altitudes in most cases. The water from these horizons is usually under artesian head of a limited amount, the pressure being sufficient to force the water often 100 and sometimes 200 feet above the bottom of the well. The supply of water from these wells is practically unlimited for domestic uses. Two towns in the area have obtained their water from these drift wells, namely, Ladd and Cherry. Town and village wells in most of the small towns such as Dover, Malden, and Arlington, are likewise deep drift wells.

The deep wells on the Hennepin Terrace differ somewhat from the others on the quadrangle. The excessive porosity of the material of which the terrace is composed makes it practically impossible to obtain an adequate water supply for farm use without sinking wells to the clay, which here is at a depth of 100 to 125 feet, depending on the surface elevation.

The alluvial sands underlying the flood plains of some of the streams, especially those on the Hennepin quadrangle are a source of a part of the water supply. These wells are usually shallow, a depth of 25 feet being sufficient ordinarily to obtain an abundant supply. The city of La Salle at present obtains its water supply from two wells located opposite the mouth of Little Vermilion River on the flood plain of Illinois River, 200 feet south of the canal. The water is obtained from a sand layer about 30 feet below the surface. The log of one of these wells is as follows:

Record of strata in well in Illinois River Valley near La Salle

	Thickness		Depth	
	Feet	*Inches*	*Feet*	*Inches*
Earth	14	6	14	6
Gravel	2	..	18	6
Earth	4	..	22	6
Gravel	12	..	34	6

Samples collected by drillers from test holes recently put down in the flood plain about one-half mile west of the La Salle city well show that the material comprising the four-foot bed of "earth" is an impermeable blue silt resembling

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very much the interglacial silts. In these localities, however, the bed is considerably thicker, averaging about 30 feet. It would seem probable that this silt extended east toward the Lower Magnesian area and the gravel derives its water mainly from that direction rather than from the Illinois River itself.

SHALLOW WELLS IN THE ROCK

Wells 100 to 150 feet deep penetrating rock but not to a sufficient depth to insure appreciable artesian effect are located at various places in the area, more especially east of the anticline. A great proportion of all the wells except those less than 25 feet deep penetrate the bed rock in these areas. On the Economic Geology map (Plate II), the distribution of the Galena-Trenton was determined by well data, and reference to the map will indicate where the horizon can be reached at moderate depth. Along the southern edge of the Galena-Trenton area, wells often penetrate the St. Peter sandstone where a more copious supply of water is generally obtained. In Waltham Township and in Dimmick Township east of Little Vermilion River the farm wells other than those that are very shallow penetrate at least to the St. Peter sandstone and a few in sections 35 and 36 of Dimmick Township and some in Utica Township penetrate the "Lower Magnesian."

A supply of water from the St. Peter is secured by penetrating the strata several feet, often as much as 50 feet, the upper part not being especially water bearing. A copious supply seems to be obtainable in all cases provided sufficient thickness of the sandstone is penetrated. The wells in the Lower Magnesian, especially if they pass through the upper limestone, tend to be artesian and will be discussed under that head. A few wells obtain water from the upper dolomite which east of the anticline apparently carries considerable water. A few wells in the vicinity of La Salle and Peru obtain water from the "Coal Measures," the beds immediately above black fissile shales being especially likely to afford a good supply of water. South of the river in Deer Park and Vermilion townships, such rock wells as are not artesian generally penetrate the "Coal Measures" to the underlying sandstone or limestone.

DEEP WELLS IN THE ROCK

Upon the Economic Geology map (Plate II), are shown by red circles the deep or artesian wells on the La Salle and Hennepin quadrangles. Only the artesian wells which enter the rock are shown, and for the most part only wells which now overflow or did formerly. Wells which have once overflowed are shown by circles. In a few cases, however, wells are regarded as artesian when they have an artesian head similar to that of other flowing wells with outlet at a lower altitude.

Artesian water is the source of the municipal water supply of several

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towns in the area; viz., Princeton, Bureau, Hennepin, Depue, Granville, Spring Valley, Peru, Oglesby, and Utica. Three zinc smelting companies, two breweries, the Western Clock Company, two cement plants, and two mines are provided with artesian wells. There are besides several wells owned by private individuals.

A few wells on the quadrangle, are either now overflowing or have overflowed, that penetrate only the "Coal Measures." In all cases these wells are coal borings and penetrate usually to La Salle (No. 2) coal or to the Pottsville formation. It is usually true that the casing which is small in the first place is pulled soon after the well is completed with the result that the well ceases to flow after a few months. The water is probably rarely from a definite horizon and the artesian effect may be due entirely to water from a gravel associated with one of the earlier drift sheets.

A number of wells at Bureau and in the vicinity, in secs. 6 and 7, Leepertown Township, sec. 1, Arispie Township, sec. 36, Princeton Township, and sec. 30, Selby Township, penetrate to the heavy dolomite underlying the Pottsville formation. The lower part of this dolomite is Niagaran and the upper part is possibly Devonian. Some of these wells, like those in Pennvanian strata, were originally coal borings.

The capacity of these wells and the head or pressure varies from place to place. The Jensen well at Bureau, located at the foot of the bluff east of the village, has a pressure of a little over two atmospheres, sufficient to raise the water to an elevation of about 580 feet above sea level. The well in sec. 1, Arispie Township, has a head of about 570 feet above sea level. At Hennepin the well has a capacity of about 30 gallons per minute with a head of about 570 feet above sea level. In the well at the Chicago Portland Cement Company at Oglesby, the head of the Niagaran water tested while the well was being drilled was 435 feet above sea level. About 25 gallons of water per minute flowed from the wells of the Mineral Point Zinc Company while boring through the Niagaran dolomite.

The Niagaran-Devonian water is brackish or salty and has a laxative effect uopn those not accustomed to it. It is generally considered unsuitable for boiler water because of its liability to foam. Where wells go below the Niagaran this water is usually cased off, allowing the sweeter water from below to rise without contamination.

The water of the Galena-Platteville formations is separated from the salt water of the Niagaran dolomite by the impervious Maquoketa shale. The Galena-Platteville is one of the most abundant aquifers of the region. The water is apparently derived from the coarse dolomitic portions of the Galena rather than from the denser Platteville. Near the anticline where these limestones are more compact they do not prove to be so abundantly water bearing.

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This horizon supplies the wells of the city of Peru, that of the Western Clock Company, the Peru Beer Company, and probably the wells of the city of Spring Valley. The well at the Star Brewing Company probably originally derived its water from this source. The water of the Cedar Point well, the Taft (B. F. Berry Coal Co.) well, the Mineral Point Zinc Company's wells, and the well of the Chicago Portland Cement Company, is derived partly from this horizon and partly from the St. Peter sandstone.

The head of this water is between 520 and 550 feet above sea level, rarely reaching the higher elevation. The capacity of the wells varies from about 200 gallons per minute to 782 gallons. The capacity of the wells seems to increase toward the west.

The St. Peter sandstone is not the exclusive source of the water in any of the artesian wells in the area. The Granville, Cedar Point, B. F. Berry Coal Company, Illinois Zinc Company, Chicago Portland Cement Company, Matthiessen and Hegeler Zinc Company, and Princeton wells derive part of their water from the Galena-Platteville horizon. The efficiency of this limestone as an aquifer makes it unnecessary in most cases to go down to the underlying sandstone. Near the anticline the limestone becomes less dolomitic and correspondingly less porous so that water must be sought in a lower bed. Analyses seem to indicate a practical uniformity in the mineral content of the water from the limestone and sandstone, and the head of the St. Peter water is about the same as that from the Galena-Platteville, that is, 520 to 550 feet above sea level.

Most of the wells in the Prairie du Chien group or "Lower Magnesian limestone" lie east of the anticline. The exceptions are wells at Illinois Zinc Company, St. Bede College, and Princeton. The wells at Utica, at Deer Park, and the one in sec. 35, Dimmick Township, derive their water from this group, and almost entirely from the New Richmond sandstone member.

The wells at Utica are probably the only ones in the area which furnish water exclusively from the "Lower Magnesian" formations. Within the corporation limits there are at present 11 artesian wells. These have an average capacity of about 140 gallons per minute, with a head about 525 feet above sea level.

The highest head of water from this formation was noted in the well in sec. 35, La Salle Township, where the water rose to an elevation of 565 feet or within 35 feet of the top of the well.

Wells at Deer Park are of about the same capacity as those at Utica, though the head is somewhat lower. Formerly the city of La Salle drew water from two wells in the river flats south of Lock 13 in the NE. ¼ sec. 13, La Salle Township. In one of these wells the head is reported not to have been over 400 feet above sea level.

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The pressure at the mouth of the well of the Illinois Zinc Company at Peru, drilled in 1916, was 13 pounds, the water coming in part at least from the New Richmond sandstone. The pressure when drilling had reached only into the St. Peter sandstone was about 6 pounds.

QUALITY OF THE WATER

The quality of the water from a number of the wells in the area is shown in the accompanying table of analyses.

SOILS

Twelve types of soil differentiated in the soil survey conducted by the Illinois Agricultural Experiment Station are found in this area.[1] These are: (1) brown silt loam found on the undulating prairies and covering the greater percentage of the area; (2) yellow-gray silt loam, along the valleys—the timber soil; (3) yellow silt loam, on the hilly areas, especially the bluffs and valleys, largely wash; (4) mixed loam, the alluvium of small streams; (5) deep brown silt loam, the alluvium of the larger streams, such as Illinois River and Lower Bureau Creek. The rest of the soils occur more sporadically. These are: (6) Black silt loam, on the poorly-drained prairies along the headwaters of most of the streams; (7) black clay loam, in association with and under similar conditions as No. 6; (8) yellow-gray silt loam on gravel terraces; (9) brown, sandy loam on rocks over the Lower Magnesian and St. Peter sandstone in Illinois River Valley east of Utica in secs. 7, 8, 17, and 18, Utica Township; (10) residual sand along the foot of the south bluff of the Illinois between Little Rock and the Utica road.

The genesis of the various soils is explained as follows:

In the La Salle and Hennepin quadrangles the brown silt loam has been formed from the loess under conditions of moderately good drainage, so that while the soil was being developed the uppermost part was being carried away.

The yellow-gray silt loam is found back from the valley walls of the streams and is similar to the brown silt loam, except that it is more porous and contains more humus, because of the shade afforded by the growing timber. Where found on terraces it is more porous than elsewhere.

The yellow silt loam is found in places where the erosion is more effective than on the rolling prairies, so that the black soil is unable to accumulate.

Mixed loam of the flood plains of smaller streams differs from the foregoing varieties in that the material of various kinds is intermittently being added to it both by flooding and hillside wash. At the same time it is thin and partakes of the character of the underlying rocks.

[1] Hopkins, Cyril G., Mosier, J. G., Pettit, J. H., and Readhimer, J. E., La Salle County Soils: University of Illinois, Agricultural Experiment Station Soil Report No. 5, 1913.

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TABLE 5—*Analyses of artesian waters in La Salle and Hennepin quadrangles*

	Utica		Mitchell Bros.		La Salle Water Works		Western Clock Co.		Illinois Zinc Co.		Peru Water Works		St. Bede College		Spring Valley Water Wks.		Mineral Pt. Zinc Co.		Jensen's Well-Bureau	
Laboratory number	23731		23730		23736		23732		23733		23735		23737		23734		23739		23738	
Parts per million of—																				
Potassium	4.5		3.9		8.5		30.4		36.5		14.9		23.8		27.6		3.9		10.8	
Sodium	12.3		17.2		21.1		192.6		499.0		469.7		156.5		183.8		98.4		762.8	
Ammonium	0.7		trace		0.37		1.3		1.4		1.4		1.4		1.4		1.2		1.4	
Magnesium	34.1		35.0		39.0		10.5		21.7		12.0		22.0		23.3		21.0		8.4	
Calcium	81.0		88.8		119.2		51.5		52.3		52.3		56.2		63.0		56.7		15.7	
Iron	1.3		0.4		0.1		0.6		0.3		1.1		2.1		0.4		trace		1.2	
Alumina	1.1		0.6		2.8		1.6		2.8		1.4		41.2		1.1		3.4		.8	
Nitrites	trace		trace		trace		.0		trace		trace		trace		.0		trace		.0	
Nitrates	1.1		1.2		5.7		5.0		0.9		0.9		0.9		11.0		0.9		0.9	
Chlorine	34.0		0.4		17.0		15.0		660.0		590.0		190.0		210.0		66.0		850.0	
Sulphate	5.4		63.7		183.8		110.2		80.1		82.3		56.5		59.6		82.3		86.2	
Silica	11.0		14.8		10.0		12.8		10.0		10.8		16.2		8.5		13.0		11.2	
Bases	0.2		0.8		12.8		.6		6.8		1.4		10.4		0.5		6.0		.8	
	Parts per mil.	Gr. per gal.	Parts per mil.	Gr. per gal.	Parts per mil.	Gr. per gal.	Parts per mil.	Gr. per gal.	Parts per mil.	Gr. per gal.	Parts per mil.	Gr. per gal.	Parts per mil.	Gr. per gal.	Parts per mil.	Gr. per gal.	Parts per mil.	Gr. per gal.	Parts per mil.	Gr. per gal.
Potassium nitrate	1.8	0.10	2.0	0.11	9.3	0.54	0.8	0.05	1.5	0.09	0.6	0.03	1.5	0.09	1.8	0.10	1.5	0.09	1.5	0.09
Potassium choloride	7.2	.42	5.9	.34	9.3	.54	57.4	3.34	68.4	3.98	27.1	1.58	44.2	2.57	51.2	2.98	6.3	.37	19.4	1.13
Sodium chloride	31.2	1.82	2.0	.11	20.8	1.21	202.5	11.81	1085.5	60.39	952.4	55.34	278.9	16.26	306.5	17.87	104.0	6.07	1387.3	80.61
Sodium sulphate	.....	.....	41.6	2.42	39.8	2.32	163.1	9.51	118.5	6.91	121.8	7.10	83.6	4.87	88.2	5.14	77.4	4.51	127.6	7.43
Sodium carbonate	.....	.....	.....	.....	.....	.....	137.8	8.04	121.0	7.06	126.6	7.38	44.9	2.61	80.0	4.67	74.3	4.33	402.5	23.47
Ammonium chloride	2.1	.12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ammonium sulphate	.....	.....	.....	.....	1.5	.09	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ammonium carbonate	.....	.....	.....	.....	.....	.....	3.5	.20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Magnesium chloride	13.8	.80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Magnesium sulphate	6.8	.40	48.2	2.81	192.8	11.24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Magnesium carbonate	101.1	5.89	87.6	5.10	2.8	.16	36.4	2.12	75.2	4.38	41.6	2.42	76.0	4.43	80.6	4.72	72.7	4.23	29.1	1.70
Calcium carbonate	202.2	11.79	219.7	12.81	295.6	11.23	128.5	7.49	130.5	7.61	130.5	7.61	140.3	8.18	157.2	9.16	141.5	8.25	39.2	2.29
Iron carbonate	3.2	.19	.8	.05	0.2	.01	1.2	.07	.6	.03	2.3	.13	4.4	.26	.8	.05	.....	.....	2.5	.15
Alumina	1.1	.06	.6	.03	5.6	.33	1.6	.09	2.4	.14	1.4	.08	41.2	2.40	1.1	.06	3.4	.19	.8	.05
Silica	11.0	.64	14.8	.86	10.0	.58	12.8	.75	10.0	.58	10.8	.65	16.2	.94	8.5	.50	13.0	.75	11.2	.65
Bases	.2	.01	.8	.05	12.8	.75	.6	.03	6.8	.39	1.4	.08	10.4	.61	.5	.03	6.0	.35	.8	.05
Total	381.7	21.64	424.0	24.69	600.5	35.00	746.2	43.5	1570.4	91.56	1420.2	82.59	745.3	43.43	780.1	45.50	503.3	29.33	2025.6	117.84

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The deep brown silt loam is formed more exclusively than the mixed loam by the action of the flood water. A thin film of sediment is deposited more or less uniformly over these areas at every time of flood. The resulting soil is the loose texture and generally somewhat sandy soil of Illinois River flood plains.

Of the less important soils, the black silt loam is formed from the loess under conditions of poor drainage and temperate humid climate. Which factors are the most important in the development of the depth and blackness of the soil is not known. The black clay loam is probably formed under similar conditions where the loess is thinner, the soil developing from the underlying clay. The brown sandy loam on the "Lower Magnesian" and St. Peter sandstone areas in the Illinois bottom is a mixture of the ordinary alluvium with the St. Peter residual and wind-blown sand. The sand soil, as its name suggests, is very porous and granular. It is the residual sand from the underlying sandstone or is in the form of dunes composed of the sand which has been blown up from the valley bottom of terrace slopes.

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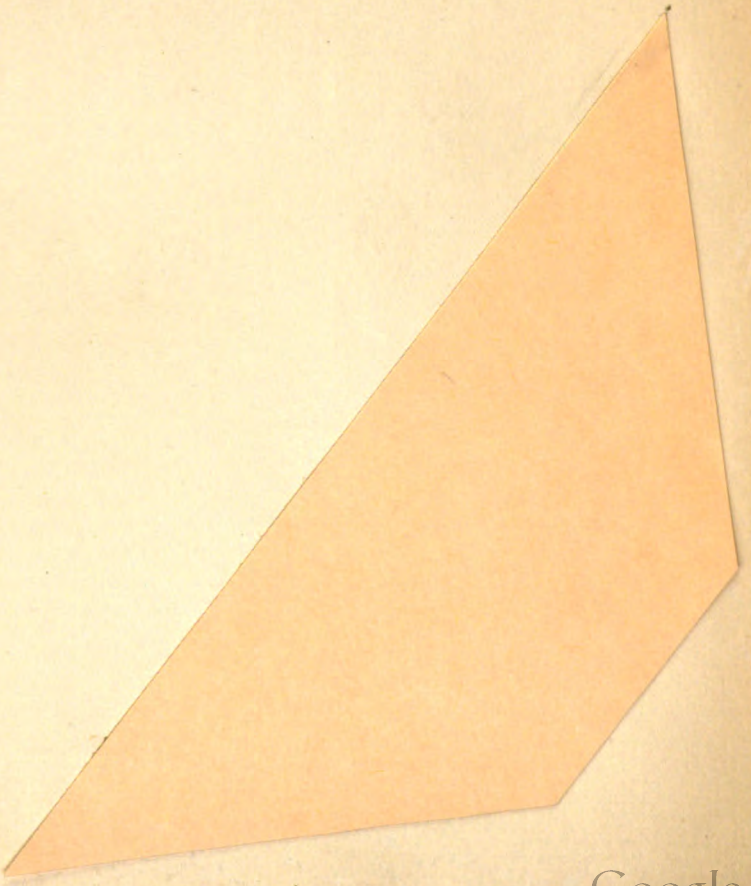

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